

FOURTH EDITION

# *EXOTIC* ANIMAL FORMULARY



JAMES W. CARPENTER

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CHRISTOPHER J. MARION, Associate Editor

# EXOTIC ANIMAL FORMULARY

## **FOURTH EDITION**

James W. Carpenter, MS, DVM, Diplomate ACZM

Professor, Zoological Medicine, Department of Clinical Sciences, College of  
Veterinary Medicine, Kansas State University, Manhattan, Kansas

Christopher J. Marion, DVM, MPH

Marion Veterinary Consulting, Manhattan, Kansas



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*Vice President:* Linda Duncan

*Content Strategy Director:* Penny Rudolph

*Content Development Specialist:* Brandi Graham

*Publishing Services Manager:* Pat Joiner-Myers

*Project Manager:* Marlene Weeks

*Design Direction:* Teresa McBryan

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## Dedication

This book is dedicated to the 34 residents and interns whom I've had the honor to train from 1991–2012, and who have brought great joy to my life and pride to our profession: Dr. Daniel V. Fredholm, Dr. Rodney Schnellbacher, Dr. Kristin Phair, Dr. Judilee Marrow, Dr. Kim Wojick, Dr. Julie Swenson, Dr. Gretchen Cole, Dr. Karen Wolf, Dr. Jessica Siegal-Willott, Dr. Jennifer D'Agostino, Dr. Adrian Mutlow, Dr. Nancy Boedeker, Dr. Robert Coke, Dr. Greg Fleming, Dr. Peter Helmer, Dr. Tama Cathers, Dr. Cornelia Ketz, Dr. Geoffrey Pye, Dr. Nancy Morales, Dr. R. Scott Larsen, Dr. Pilar Hayes, Dr. Cynthia Stadler, Dr. Ray Ball, Dr. Christine Kolmstetter, Dr. James K. Morrissey, Dr. Edward Gentz, Dr. Lisa Harrenstien, Dr. Janette Ackermann, Dr. Ted Y. Mashima, Dr. Sandra C. Wilson, Dr. Craig A. Harms, Dr. Mel Shaw, and Dr. Mitch Finnegan.

James W. Carpenter

I dedicate this book to my wife, Landa, without whose support I would not be the veterinarian I am today. I thank her for all of her patience and understanding during those months that I always seemed to have a draft chapter to edit. I am also indebted to Dr. James W. Carpenter for including me on this project, in addition to the many opportunities in exotic animal medicine that I have had over the years that can be directly or indirectly linked to him.

Christopher J. Marion

## Contributors

Heather W. Barron, DVM, Diplomate ABVP (Avian)

Department Head, Veterinary Clinical Sciences, Professor, Small & Exotic Animal Medicine, School of Veterinary Medicine, St. Matthew's University, Grand Cayman, Cayman Islands, British West Indies

David M. Brust, DVM

President of the Association of Sugar Glider Veterinarians, Sugar Land Pet Hospital, Sugar Land, Texas

James W. Carpenter, MS, DVM, Diplomate ACZM

Professor, Zoological Medicine, Department of Clinical Sciences, College of Veterinary Medicine, Kansas State University, Manhattan, Kansas

Ryan S. DeVoe, DVM, MSPVM, Diplomate ACZM, Diplomate ABVP (Avian)

Senior Veterinarian, North Carolina Zoological Park, Ashboro, North Carolina

Stephen J. Divers, BVetMed, DZooMed, Diplomate ACZM, Diplomate ECZM, Fellow and Recognised Specialist RCVS

Professor, Zoological Medicine, Department of Small Animal Medicine and Surgery, College of Veterinary Medicine, University of Georgia, Athens, Georgia

Christine V. Fiorello, MS, DVM, PhD, Diplomate ACZM

Response Veterinarian, Oiled Wildlife Care Network, Wildlife Health Center, School of Veterinary Medicine, University of California–Davis, Davis, California

Paul M. Gibbons, DVM, MS, Diplomate ABVP (Avian, Reptile/Amphibian)

Managing Director and Veterinarian, Turtle Conservancy Behler Chelonian Center, Ojai, California

Natalie H. Hall, DVM

Resident, Zoological Medicine, Department of Small Animal Clinical Science,  
College of Veterinary Medicine, University of Florida, Gainesville, Florida

Michelle G. Hawkins, VMD, Diplomate ABVP (Avian)

Associate Professor, Companion Avian and Exotic Animal Medicine and Surgery,  
Department of Medicine and Epidemiology, School of Veterinary Medicine,  
University of California–Davis, Davis, California

Eric Klaphake, DVM, Diplomate ACZM, Diplomate ABVP (Avian)

Associate Veterinarian, Cheyenne Mountain Zoo, Colorado Springs, Colorado

Marie-Josée Lemoy, DMV, IPSAV

Senior Veterinarian, California National Primate Center, University of California–  
Davis, Davis, California

Gregory A. Lewbart, MS, VMD, Diplomate ACZM

Professor, Aquatic Animal Medicine, Department of Clinical Sciences, College of  
Veterinary Medicine, North Carolina State University, Raleigh, North Carolina

Christopher J. Marion, DVM, MPH

Marion Veterinary Consulting, Manhattan, Kansas

Jörg Mayer, DVM, MSc, Diplomate ABVP (ECM), Diplomate ECZM (Small  
Mammal)

Associate Professor, Zoological Medicine, Department of Small Animal Medicine  
and Surgery, College of Veterinary Medicine, University of Georgia, Athens,  
Georgia

David L. McRuer, MSc, DVM, Diplomate ACVPM

Director of Veterinary Services, Wildlife Center of Virginia, Waynesboro,  
Virginia

James K. Morrissey, DVM, Diplomate ABVP (Avian)

Companion Exotic Animal Medicine Service, Department of Clinical Sciences,  
College of Veterinary Medicine, Cornell University, Ithaca, New York

Christal Pollock, DVM, Diplomate ABVP (Avian)

Lafeber Company Veterinary Consultant, Cleveland Heights, Ohio

Geoffrey W. Pye, BVSc, MSc, Diplomate ACZM

Senior Veterinarian, San Diego Zoo Veterinary Services, San Diego, California

Brian L. Speer, DVM, Diplomate ABVP (Avian), Diplomate ECZM (Avian)

Medical Center for Birds, Oakley, California

Julie Swenson, DVM

Staff Veterinarian, The Phoenix Zoo, Phoenix, Arizona

Valarie V. Tynes, DVM, Diplomate ACVB

Premier Veterinary Behavior Consulting, Sweetwater, Texas

Celia R. Valverde, DVM, Diplomate ACVS

Assistant Clinical Professor, University of California–Davis, Davis, California

VCA-Sacramento Veterinary Referral Center, Sacramento, California

Kevin Wright, DVM, Diplomate ABVP (Reptile and Amphibian)

Arizona Exotic Animal Hospital, Mesa, Arizona

## Preface

As we know, the medical care of exotic pets has become an integral part of most companion animal practices. This fourth edition of the *Exotic Animal Formulary*, therefore, was initiated to accommodate this rapid growth of exotic animal medicine. For this revision, many of the most recognized specialists in our field were invited to contribute; their role was to evaluate published drug dosages, related biologic and medical information, and references, and to select those that would be most clinically useful and relevant to the practitioner.

Not only is this edition updated, expanded, and in color, but we've added a section on invertebrates in addition to sections on fish, amphibians, reptiles, birds, sugar gliders, hedgehogs, rodents, rabbits, ferrets, miniature pigs, primates, and wildlife. The appendix, Selected Topics for the Exotic Animal Veterinarian, has also been expanded and now includes information on exotic animal online resources for practitioners as well as captive husbandry websites.

This book is not intended to replace existing medical resources or the use of sound medical judgment, but rather to serve as a guide in providing medical care to exotic animals. This formulary assumes that the reader has a reasonable understanding of veterinary medicine. For example, drug indications are generally listed only in unique situations. Supporting tables have been carefully selected to include those topics of major importance in clinical practice.

As in previous editions of this book, the selection of species, drugs, and other information used in this reference was based on an extensive review of the literature and on our collective teaching and clinical experience. The book, therefore, is intended not to be all-inclusive, but rather a quick reference for the common questions and medical situations we encounter in clinical practice.

Unfortunately, though, relatively few pharmacodynamic studies in exotic companion pets are relevant to the medications we use in practice. Until more pharmacokinetic, efficacy, and safety studies of the drugs that we use are conducted, most dosages used in these species are based on empirical data, observations, and experience.

This book is intended to be a practical, user-friendly, quick reference for

veterinary clinicians, students, and technicians working with exotic animals. We hope, therefore, that you find this formulary and accompanying tables handy to use and that it adds to the quality of the medical care you provide to your exotic animal patients. Because exotic animal practitioners face daily challenges to meet the pharmaceutical and clinical needs of their patients, our hope is that this book will be a valuable tool in helping meet these challenges.

James W. Carpenter, MS, DVM, Diplomate ACZM



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This book would not have been possible without the invaluable assistance of many dedicated and hard-working people. Certainly, first and foremost, my appreciation goes to Dr. Christopher J. Marion, who, as the Associate Editor for this edition of the *Exotic Animal Formulary*, provided editorial assistance, technical expertise, and personal encouragement. Without his hard work, the fourth edition would still be a book in progress. I am also greatly appreciative of the numerous contributors who unselfishly shared their expertise and gave of their time, and are largely responsible for the success of this book! I am indebted to Caitlin Burrell, Amy Guernsey, and Robert Martinez for assistance in the preparation of this formulary; to Mal Rooks Hoover, Certified Medical Illustrator, for providing input on the cover design; to Dr. Karen Overall for reviewing the table on avian psychotherapeutic agents; and to Dr. Butch KuKanich for reviewing the appendix on antimicrobial agents.

I also wish to thank all those colleagues who encouraged me in the preparation of the *Exotic Animal Formulary*, fourth edition. When I heard comments such as “our practice has 5 EAF’s, but we can never find them when we need them,” it lets me know that the efforts into preparing this book are appreciated by the veterinary community and provides a powerful incentive for me to continue working on this reference.

I also thank Penny Rudolph, Brandi Graham, and Carol O’Connell, our publishing team at Elsevier, for their patience and support, and to their commitment to this fourth edition.

James W. Carpenter

# Disclaimer

The Editor, Associate Editor, and the Contributors attempted to verify and double-check all references, dosages, and other data contained in this book. However, despite these efforts, errors in the original sources or in the preparation of this book may have occurred. All users of this reference, therefore, should empirically evaluate all dosages to determine that they are reasonable prior to use. The publisher assumes no responsibility for and makes no warranty with respect to results obtained from the uses, procedures, or dosages listed, or for any misstatement or error, negligent or otherwise, contained in this book. In addition, the authors do not necessarily endorse specific products, procedures, or dosages reported in this book. Also, the listing of a drug or commercial product in this book does not indicate approval by the FDA or the manufacturer for use in exotic animals.



# About the editor

**James W. Carpenter, MS, DVM, Diplomate ACZM**, is a Professor at the College of Veterinary Medicine, Kansas State University, where he heads the Zoological Medicine Service. He has been a clinical and research veterinarian for 37 years in the field of exotic animal, wildlife, and zoo animal medicine, and has trained 34 interns and residents. He is the author of numerous scientific papers and book chapters; is co-author/editor of the *Exotic Animal Formulary* (1996, 2001, 2005, 2013) and its Japanese (2002), Spanish (2006), and Portuguese (2010) translations; and is co-editor of *Ferrets, Rabbits, and Rodents: Clinical Medicine and Surgery* (2004, 2012). Dr. Carpenter was the Editor of the *Journal of Zoo and Wildlife Medicine* (1987–1992) and Chair of its Editorial Board (1992–1997), member of the Editorial Board for *Seminars in Avian and Exotic Pet Medicine* (1994–2005), on the Wildlife Scientific Advisory Board of the Morris Animal Foundation (1998–2001; Chair, 2000–2001), President of the American Association of Zoo Veterinarians (1998–1999), President (2007) and member of the Board of Directors of the Association of Avian Veterinarians (2005–2008), Treasurer (2003–2007) of the American College of Zoological Medicine, and was named Exotic DVM of the Year for 2000. Dr. Carpenter received a Special Service Award for recipient's contributions to animal health, Morris Animal Foundation, 2001, and the Emil Dolensek Award, American Association of Zoo Veterinarians, 2004. In 2002, Dr. Carpenter was awarded the Edwin J. Frick Professorship in Veterinary Medicine from the KSU College of Veterinary Medicine, named an Alumni of the Year by the Oklahoma State University College of Veterinary Medicine (2009), and was the Exotic Speaker of the Year for the 2010 Western Veterinary Conference. Dr. Carpenter is currently the Editor-in-Chief of the *Journal of Avian Medicine and Surgery* (1994–present), on the Editorial Board of the *Journal of Exotic Pet Medicine*, and Immediate Past-President and member of the Executive Committee of the American College of Zoological Medicine.

# About the associate editor

**Christopher J. Marion, DVM, MPH**, received his Doctor of Veterinary Medicine and Master of Public Health degrees from Kansas State University. He has overseen clinical trials in the clinical research industry for the past 5 years. During this time, he also consulted with the Association of Avian Veterinarians on the quarterly publication of the *Journal of Avian Medicine and Surgery*. Additionally, he recently assisted in the editing of *Ferrets, Rabbits, and Rodents: Clinical Medicine and Surgery*, Third Edition.

## Abbreviations

**d** day

**EpiCe** epicoelomic

**h, hr** hour

**HR** heartrate

**ICe** intracoelomic

**IM** intramuscularly

**IO** intraosseous

**IP** intraperitoneally

**IPPV** intermittent positive pressure ventilation

**IV** intravenously

**IU** international units

**kg** kilogram

**L** liter

**LRS** lactated Ringer's solution

**mg** milligram

**min** minute

**mo** month

**PD** pharmacodynamic/pharmacologic data

**PK** pharmacokinetic data

**PO** orally

**prn** as needed

**q** every

**RR** respiratory rate

**SC** subcutaneously

**wk** week

TABLE 1-1 Antimicrobial and Antifungal Agents Used in Invertebrates.<sup>a-e</sup>

| Agent                         | Dosage                                                                                                                         | Comments                                                                                                                                                                                                                                                                                                                             |
|-------------------------------|--------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Benzalkonium chloride         | 0.5 mg/L long-term <sup>66</sup>                                                                                               | Quaternary amine with broad disinfection properties                                                                                                                                                                                                                                                                                  |
|                               | 10 mg/L for 10 min <sup>56</sup>                                                                                               |                                                                                                                                                                                                                                                                                                                                      |
| Ceftazidime (Fortaz, Pfizer)  | 20 mg/kg intracardiac q72h × 3 wk <sup>56</sup>                                                                                | Spiders/cephalosporin with good activity against Gram-negative bacteria (e.g., <i>Pseudomonas</i> ); although this regimen appears safe, efficacy has not been determined                                                                                                                                                            |
| Chloramphenicol               | 75 mg/kg PO, IM q12h × 6 days <sup>59</sup>                                                                                    | Cephalopods                                                                                                                                                                                                                                                                                                                          |
|                               | 10-50 mg/L as an immersion treatment for several days <sup>10,62,64</sup> (prepare fresh solution with 100% water change q24h) | Corals/reduce lighting for treated animals if possible (slows metabolic rate and may reduce stress and improve drug tolerance); rinse animals well with fresh seawater before return to primary habitat; properly treat any effluent before discharge; florfenicol may be a better alternative (risk to humans from chloramphenicol) |
| Enrofloxacin (Baytril, Bayer) | 5 mg/kg IM, IV <sup>28,59</sup>                                                                                                | Cuttlefish and possibly other cephalopods                                                                                                                                                                                                                                                                                            |
|                               | 5 mg/kg IV <sup>56</sup>                                                                                                       | Spiders                                                                                                                                                                                                                                                                                                                              |
|                               | 10 mg/kg PO <sup>28,59</sup>                                                                                                   | Cuttlefish and possibly other cephalopods                                                                                                                                                                                                                                                                                            |
|                               | 10-20 mg/kg IM <sup>65</sup>                                                                                                   | Chinese mitten crabs/PD                                                                                                                                                                                                                                                                                                              |
|                               | 10-20 mg/kg PO q24h <sup>56</sup>                                                                                              | Spiders                                                                                                                                                                                                                                                                                                                              |
|                               | 2.5 mg/L × 5 hr immersion q12-24h <sup>28,59</sup>                                                                             | Cuttlefish and possibly other cephalopods                                                                                                                                                                                                                                                                                            |
| Fluconazole                   | 3 mg/kg q4d × 6 treatments <sup>60</sup>                                                                                       | Horseshoe crabs                                                                                                                                                                                                                                                                                                                      |



|                                  |                                                                                              |                                                                                                                                                                                                                                                                 |
|----------------------------------|----------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Formalin                         | 1-1.5 ppm <sup><a href="#">37</a></sup>                                                      | Horseshoe crabs/ectocommensals                                                                                                                                                                                                                                  |
| Furazolidone                     | 50 mg/L q12h for 10 min immersion <sup><a href="#">59</a></sup>                              | Cephalopods                                                                                                                                                                                                                                                     |
| Iodine, Lugol's 5% solution      | 5-10 drops/L of seawater; use as an immersion for 10-20 min <sup><a href="#">10,64</a></sup> | Corals/antiseptic; cauterize wounds; strong oxidizing agent; some corals are sensitive, including pulse corals ( <i>Xenia</i> sp), <i>Anthelia</i> spp, and star polyps ( <i>Pachyclavularia</i> spp); remove corals at first signs of stress (polyp expulsion) |
|                                  | Topically at full strength (5%) for 20-30 sec <sup><a href="#">64</a></sup>                  |                                                                                                                                                                                                                                                                 |
| Itraconazole (Sporanox, Janssen) | 10 mg/kg IV <sup><a href="#">1</a></sup>                                                     | Horseshoe crabs/PD                                                                                                                                                                                                                                              |
| Nitrofurazone                    | 1.5 mg/L for 72 hr <sup><a href="#">59</a></sup> immersion                                   | Cephalopods/nitrofurazone; carcinogenic; drug inactivated in bright light; water soluble formulations preferred                                                                                                                                                 |
|                                  | 25 mg/L q12h for 1 hr <sup><a href="#">59</a></sup> immersion                                |                                                                                                                                                                                                                                                                 |
| Nystatin                         | 50 mg/mL for surface "sterilization" of aquatic nematodes <sup><a href="#">8,47</a></sup>    |                                                                                                                                                                                                                                                                 |
| Oxolinic acid                    | 10 mg/kg intrasinus <sup><a href="#">67</a></sup>                                            | Kuruma shrimp/PD; quinolone; Gram-negative bacteria; decreased uptake in hard water; better uptake pH <6.9                                                                                                                                                      |
|                                  | 50 mg/kg PO <sup><a href="#">67</a></sup>                                                    |                                                                                                                                                                                                                                                                 |
| Oxytetracycline                  | 10 mg/kg intrasinus <sup><a href="#">67,68</a></sup>                                         | Tiger shrimp/PD; cooking reduced muscle levels by 30-60% and shell levels by 20%                                                                                                                                                                                |
|                                  | 25 mg/kg intrasinus <sup><a href="#">67</a></sup>                                            | Kuruma shrimp/PD                                                                                                                                                                                                                                                |
|                                  | 25-50 mg/kg IV <sup><a href="#">52</a></sup>                                                 | Horseshoe crabs/PD                                                                                                                                                                                                                                              |
|                                  | 50 mg/kg PO <sup><a href="#">67,68</a></sup>                                                 | Kuruma shrimp/PD; tiger shrimp/PD; cooking reduced muscle levels by 30-60% and shell levels by 20%                                                                                                                                                              |
|                                  | 100 mg/kg PO <sup><a href="#">57</a></sup>                                                   | White shrimp/PD                                                                                                                                                                                                                                                 |
|                                  | 200 mg/colony q4-5d × 3 treatments <sup><a href="#">70</a></sup>                             | Honeybees/for treating American and European foulbrood; withdrawal time of 6 wk; should not be used on hives where honey will be consumed                                                                                                                       |

|                                                              |                                                                 |                                                                                                                                                                                                                            |
|--------------------------------------------------------------|-----------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                                                              |                                                                 | by humans                                                                                                                                                                                                                  |
|                                                              | 10-15 mg/L q48-72h × 3-5 treatments <sup>33</sup>               | Chocolate chip sea stars/cutaneous ulcerations; may be applicable to other echinoderms with bacterial lesions                                                                                                              |
|                                                              | 1 g/lb of feed <sup>51</sup>                                    | American lobsters/gaffkemia; approved for use in food animals by the FDA                                                                                                                                                   |
| Silver sulfadiazine cream (Silvadene, Marion Merrill Dow)    | Apply topically to lesions                                      | Proceed with caution (biotest if possible) as treatments are empirical                                                                                                                                                     |
| Sulfadimethoxine                                             | 50-100 mg/kg in feed × 14 days <sup>51</sup>                    | Penaeid shrimp                                                                                                                                                                                                             |
| Sulfadimethoxine/ormetoprim (Romet-30, Alpharma)             | 42 mg/kg intrapericardial <sup>4</sup>                          | American lobster/PD                                                                                                                                                                                                        |
| Sulfamethoxazole/trimethoprim                                | Bioencapsulated in brine shrimp PO q12h <sup>13,40,49,50</sup>  | White shrimp/PD; combine 20-40% trimethoprim sulfamethoxazole with a lipid emulsion (Selco, INVE Aquaculture) at a concentration of 1:5                                                                                    |
| Tetracycline                                                 | 10 mg/kg PO q24h <sup>59</sup>                                  | Cephalopods                                                                                                                                                                                                                |
|                                                              | 10 mg/L bath <sup>36,64</sup>                                   | Corals/efficacy questionable in saltwater; anecdotal evidence of successful treatment for bacterial infections                                                                                                             |
| Trifluralin                                                  | 0.01-0.1 ppm as an immersion <sup>51</sup>                      | Penaeid shrimp/larval oomycetosis                                                                                                                                                                                          |
| Tris EDTA and neomycin (Tricide-Neo, Molecular Therapeutics) | 100 mL/L for 45 min q24h × 7 days as an immersion <sup>33</sup> | Cushion sea stars/cutaneous ulcers; may be applicable to other echinoderms                                                                                                                                                 |
| Tylosin (Tylan, Elanco)                                      | 200 mg/colony q7d × 3 treatments <sup>70</sup>                  | Honeybees/antibiotic applied topically to the brood chamber for control of American foulbrood ( <i>Paenibacillus larvae</i> ); approved by the FDA; should not be used in hives where the honey will be consumed by humans |
| Winter savory extract ( <i>Satureja montana</i> )            | 0.01% in microcrystalline sugar <sup>15</sup>                   | Honeybees/chalkbrood fungal disease ( <i>Ascosphaera apis</i> ); a number of plant aromatic oils have been tested, some with more promise than others, on various diseases of honeybees <sup>20,70</sup>                   |

<sup>a</sup> Not to be used with invertebrates intended for human consumption unless government approved.

- <sup>b</sup> Preferable to treat a single animal of a species (biotest) to determine toxicity.
- <sup>c</sup> Tank treatment: when treating the invertebrates' resident aquarium, disconnect activated carbon filtration to prevent drug removal. Many drugs adversely affect the nitrifying bacteria, so water quality should be monitored closely (especially ammonia and nitrite concentrations). Keep water well aerated when appropriate and monitor patient(s) closely. Perform water changes and reconnect filtration to remove residual drug following treatment. Discard carbon following drug removal.
- <sup>d</sup> Bath (immersion) treatment: remove invertebrates from resident aquarium and place in container with known volume of water and concentration of therapeutic agent. Watch closely for signs of toxicity.
- <sup>e</sup> Invertebrate species, temperature, and water quality parameters can influence the pharmacodynamics of many drugs, especially antimicrobials.

TABLE 1-2 Antiparasitic Agents Used in Invertebrates. [a-e](#)

| Agent                | Dosage                                                                       | Comments                                                                                                                                                                                                                                      |
|----------------------|------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Acetic acid, glacial | 3-5% solution for 1 hr <sup><a href="#">12</a></sup>                         | Horseshoe crabs                                                                                                                                                                                                                               |
| Amitraz              | Use as directed <sup><a href="#">70</a></sup>                                | Honeybees/acariasis; commercial packaging should be consulted prior to use                                                                                                                                                                    |
| Chromic acid         | 0.2% immersion for several min <sup><a href="#">9,58</a></sup>               | Turbellarians/ <i>Urceolaria</i> protozoans                                                                                                                                                                                                   |
| Formalin             | 50-100 µL/L for 4 hr or 25 µL/L indefinitely <sup><a href="#">51</a></sup>   | Shrimp/protozoal ectoparasites; approved for use by the FDA in food animals                                                                                                                                                                   |
| Formic acid          | Use as directed <sup><a href="#">70</a></sup>                                | Honeybees/acariasis; commercial packaging should be consulted prior to use                                                                                                                                                                    |
| Freshwater           | 1-3 min dip <sup><a href="#">64</a></sup>                                    | Stony corals, some soft corals/flatworms, and other ectoparasites; buffer to pH 8.2 and use clean, dechlorinated water; do not use on small polyp corals or xenids; biotest first, if possible, especially when attempting with a new species |
| Fumagillin           | Use as directed <sup><a href="#">70</a></sup>                                | Honeybees/nosemosis (caused by microsporidian parasites); commercial packaging should be consulted prior to use                                                                                                                               |
| Ivermectin           | Stock solution of 1:1 (1% ivermectin and propylene glycol); dilute 1:50 with | Spiders/for the treatment of individual parasitic mites; apply carefully to mites with fine paintbrush or similar                                                                                                                             |

|                                          |                                                                       |                                                                                                                                                                                 |
|------------------------------------------|-----------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                                          | distilled water prior to topical use <sup>56</sup>                    | implement                                                                                                                                                                       |
| Levamisole (Levasole, Schering Plough)   | 8 mg/L immersion for 24 hr <sup>64</sup>                              | Corals/metazoan parasites; well tolerated by <i>Acropora</i> spp, <i>Montipora digitata</i> , <i>M. capricornis</i> , <i>Seriatopora hystrix</i> , <i>Stylophora pistillata</i> |
| Menthol                                  | Use as directed <sup>70</sup>                                         | Honeybees/acariasis; commercial packaging should be consulted prior to use                                                                                                      |
| Metronidazole                            | 50 mg/kg intracardiac × 1 treatment <sup>56</sup>                     | Spiders/appears safe, but efficacy is unknown                                                                                                                                   |
|                                          | 100 mg/L for 16 hr <sup>59</sup>                                      | Cephalopods/antiprotozoal                                                                                                                                                       |
| Milbemycin oxime (Interceptor, Novartis) | 0.625 mg/L as an immersion <sup>24,32,38</sup>                        | Stony corals ( <i>Acropora</i> )/“red bug” ( <i>Tegastes acroporans</i> )                                                                                                       |
| Potassium permanganate                   | 25-30 ppm for 30-60 min <sup>51</sup>                                 | Penaeid shrimp/external parasiticide                                                                                                                                            |
| Povidone iodine                          | 0.75% solution for topical treatment <sup>56</sup>                    | Spiders/fungal infections; use water based solution                                                                                                                             |
| Thymol                                   | Use as directed <sup>70</sup>                                         | Honeybees/acariasis; commercial packaging should be consulted prior to use                                                                                                      |
| Triton X-100 (Sigma)                     | Culture turbellarian eggs in 0.25-1% solution for 4 days <sup>9</sup> | Turbellarian eggs/protozoan ( <i>Thraustochytrium caudivorum</i> )                                                                                                              |

<sup>a</sup> Not to be used with invertebrates intended for human consumption unless government approved.

<sup>b</sup> Preferable to treat a single animal of a species (biotest) to determine toxicity.

<sup>c</sup> Tank treatment: when treating the invertebrates’ resident aquarium, disconnect activated carbon filtration to prevent drug removal. Many drugs adversely affect the nitrifying bacteria, so water quality should be monitored closely (especially ammonia and nitrite concentrations). Keep water well aerated when appropriate and monitor patient(s) closely. Perform water changes and reconnect filtration to remove residual drug following treatment. Discard carbon following drug removal.

<sup>d</sup> Bath (immersion) treatment: remove invertebrates from resident aquarium and place in container with known volume of water and concentration of therapeutic agent. Watch closely for signs of toxicity.

<sup>e</sup> Invertebrate species, temperature, and water quality parameters can influence the pharmacodynamics of many drugs.

TABLE 1-3 Chemical Restraint/Anesthetic/Analgesic Agents Used in Invertebrates.

| Agent               | Dosage                                                         | Comments                                                                                                                                                                                                                                                                                |
|---------------------|----------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Benzocaine          | 100 mg/L <sup>2,30</sup>                                       | Abalone/anesthesia; not sold as anesthetic in United States; available from chemical supply companies; do not use topical anesthetic products marketed for mammals; prepare stock solution in ethanol (benzocaine is poorly soluble in water); store in dark bottle at room temperature |
|                     | 400 mg/L <sup>19</sup>                                         | Leeches/this could be applied, with caution, to other aquatic annelids                                                                                                                                                                                                                  |
|                     | 2.5-3 g/L <sup>59</sup>                                        | Cephalopods/euthanasia                                                                                                                                                                                                                                                                  |
| Butorphanol         | Fish, amphibian, and reptile dosages can be employed with care | Analgesia; use with caution as dosing regimens are empirical; biotest when possible                                                                                                                                                                                                     |
| Carbon dioxide      | Blow gas over animal <sup>9,41</sup>                           | Terrestrial turbellarians/euthanasia                                                                                                                                                                                                                                                    |
|                     | 3-5% <sup>31</sup>                                             | Terrestrial arthropods/euthanasia; isoflurane and sevoflurane may be preferable with regard to recovery; an anesthetic chamber has been developed/described for use in the fruit fly <sup>71</sup>                                                                                      |
| Chloretone          | 0.1% <sup>9,55</sup>                                           | Turbellarians/anesthesia                                                                                                                                                                                                                                                                |
| Clove oil (eugenol) | 0.125 mL/L (approx. 125 mg/L) as an immersion <sup>26</sup>    | Crustaceans/stock solution: 100 mg/mL of eugenol by diluting 1 part clove oil with 9 parts 95% ethanol (eugenol is poorly soluble in water); over-the-counter preparation (pure) available at most pharmacies contains approximately 1 g eugenol per mL clove oil                       |
| Ethanol             | 1.5-3% solution <sup>34</sup>                                  | Cuttlefish/may not be effective for cold water cephalopods <sup>30</sup>                                                                                                                                                                                                                |
|                     | 3% solution <sup>30</sup>                                      | Abalone                                                                                                                                                                                                                                                                                 |
|                     | 5% solution <sup>25,31</sup>                                   | Aquatic gastropods                                                                                                                                                                                                                                                                      |
|                     | 5% solution <sup>16,42</sup>                                   | Oligochaetes/adequate for terrestrial earthworms such as <i>Lumbricus terrestris</i>                                                                                                                                                                                                    |
|                     | 10% solution <sup>6,9,55,73</sup>                              | Turbellarians/anesthesia                                                                                                                                                                                                                                                                |
|                     | 10% solution <sup>59</sup>                                     | Cephalopods/euthanasia                                                                                                                                                                                                                                                                  |
|                     |                                                                |                                                                                                                                                                                                                                                                                         |

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|-----------------------------------------------|---------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Ethanol/menthol<br>(Listerine,<br>McNeil-PPC) | 10% in saline <sup>74</sup>                                                           | Aquatic gastropods/anesthesia                                                                                                                                                                                                                                                  |
| Hydroxylamine<br>hydrochloride                | 1% solution <sup>9,55</sup>                                                           | Turbellarians/anesthesia                                                                                                                                                                                                                                                       |
| Ice                                           | Used to effect; <sup>9,22</sup><br>pure ice water can<br>also be used <sup>9,55</sup> | Turbellarians/sedation; cover ice with filter paper to protect<br>the flatworms                                                                                                                                                                                                |
| Isoflurane                                    | Can be used with<br>an anesthetic<br>chamber                                          | Terrestrial gastropods, <sup>27</sup> arachnids <sup>17,23,45,56</sup> /anesthesia; fast<br>induction with a possible excitatory period; anesthetic depth<br>may not be appropriate for invasive surgery; <sup>27</sup> usually applied<br>at a 5% concentration for arachnids |
| Ketamine                                      | 40-90 mcg/g IM <sup>11</sup>                                                          | Crayfish/induction time of less than 1 min and anesthetic<br>duration of 10 min at low dose and 2 hr at high dose                                                                                                                                                              |
|                                               | 0.025-1 mg/kg <sup>26</sup>                                                           | Australian giant crabs/fast induction (less than 30 sec) with an<br>excitatory phase; dose dependent anesthetic duration of 8-40<br>min                                                                                                                                        |
| Lidocaine                                     | 0.4-1 mg/g IM <sup>11</sup>                                                           | Crayfish/induction time of less than 2 min and duration of<br>anesthesia of 5-30 min when injected into the tail                                                                                                                                                               |
| Magnesium<br>chloride                         | Intracoelomic <sup>14</sup>                                                           | Sea hares/short induction time (2-5 min) and good muscle<br>relaxation                                                                                                                                                                                                         |
|                                               | 6.8 g/L <sup>28,30</sup>                                                              | Cephalopods/induction time of 6-12 min in cuttlefish                                                                                                                                                                                                                           |
|                                               | 30-50 g/L <sup>35</sup>                                                               | Scallops/fast induction and recovery                                                                                                                                                                                                                                           |
|                                               | 1:1 isotonic salt<br>and seawater as an<br>immersion <sup>7,9</sup>                   | Marine turbellarians                                                                                                                                                                                                                                                           |
|                                               | 1:1 mixture of<br>7.5% with<br>seawater <sup>33,44</sup>                              | Echinoderms/concentration adjustments may be required for<br>prolonged anesthesia                                                                                                                                                                                              |
|                                               | 7.5%<br>immersion <sup>40,48</sup>                                                    | Polychaetes                                                                                                                                                                                                                                                                    |
|                                               | 10% solution prn <sup>59</sup>                                                        | Cephalopods/euthanasia                                                                                                                                                                                                                                                         |
| Magnesium<br>sulfate                          | Intracoelomic <sup>14</sup>                                                           | Sea hares (sea snails; <i>Aplysia</i> )/short induction time (2-5 min)<br>and good muscle relaxation                                                                                                                                                                           |
|                                               | 4-22 g/100 mL <sup>72</sup>                                                           | Abalone/fast induction and good recovery                                                                                                                                                                                                                                       |
| MS-222<br>(Finquel, Argent)                   | —                                                                                     | See tricaine methanesulfonate                                                                                                                                                                                                                                                  |
| 2-<br>phenoxyethanol                          | 0.5-3 mL/L <sup>72</sup>                                                              | Abalone/quick induction and short recovery                                                                                                                                                                                                                                     |
|                                               | 1-2 mL/L <sup>30</sup>                                                                | Quick induction and short recovery                                                                                                                                                                                                                                             |
|                                               |                                                                                       |                                                                                                                                                                                                                                                                                |



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| Potassium chloride                                  | 1 g/kg (330 mg/mL solution)                                                                                               | Lobsters/euthanasia; inject at base of second walking leg                                                                                                                                                                                                                                                                                                              |
| Procaine                                            | IV <sup>5</sup><br>25 mg/kg IV <sup>54</sup>                                                                              | Crabs/very short induction time (less than 30 sec) and prolonged anesthesia (2-3 hr)                                                                                                                                                                                                                                                                                   |
| Propylene phenoxetol                                | 1-3 mL/L of a 1% solution <sup>30,46,53</sup>                                                                             | Oysters/anesthesia; this concentration should produce anesthesia in less than 15 min; recovery time is short (under 30 min); higher doses can be used but induce a deeper level of anesthesia; can also be used for giant clams <sup>46</sup>                                                                                                                          |
|                                                     | 2 mL/L <sup>30,69</sup>                                                                                                   | Echinoderms                                                                                                                                                                                                                                                                                                                                                            |
| Sevoflurane                                         | Can be used with an anesthetic chamber at a 5% concentration <sup>30</sup>                                                | Terrestrial arthropods/see isoflurane for details of administration                                                                                                                                                                                                                                                                                                    |
| Sodium azide                                        | 100 mM <sup>3,8</sup>                                                                                                     | Nematodes ( <i>Caenorhabditis elegans</i> )/anesthesia; can survive for 2 hr without apparent harm; sodium azide is a plant and animal cell mutagen; proper hygiene and handling is advised                                                                                                                                                                            |
| Sodium bicarbonate tablets (Alka-Seltzer, Bayer)    | 2-4 tablets/L bath <sup>29</sup>                                                                                          | Euthanasia; generates CO <sub>2</sub> ; use when other agents unavailable; keep aquatic invertebrate in solution >10 min after respiration stops; dosage based on piscine literature                                                                                                                                                                                   |
| Sodium pentobarbital                                | 400 mg/L <sup>43</sup>                                                                                                    | Aquatic gastropods/anesthesia; very slow onset but apparently safe; controlled drug                                                                                                                                                                                                                                                                                    |
|                                                     | 1 mL/L <sup>2</sup>                                                                                                       | Abalone                                                                                                                                                                                                                                                                                                                                                                |
| Tricaine methanesulfonate (MS-222; Finquel, Argent) | Dosages and efficacy vary widely depending on species and application; consult taxon-specific literature <sup>30,31</sup> | Anesthesia; stock solution: 10 g/L, buffer the acidity by adding sodium bicarbonate at 10 g/L or to saturation; store stock in dark container; shelf-life of stock extended by refrigeration or freezing; stock that develops an oily film should be discarded; aerate water to prevent hypoxemia; euthanasia: keep animal in solution >20 min after respiration stops |
| Xylazine                                            | 16-22 mg/kg IV <sup>26</sup>                                                                                              | Giant crabs/fast induction (3-5 min) and approx 30 min of anesthesia (dose dependent)                                                                                                                                                                                                                                                                                  |

TABLE 1-4 Miscellaneous Agents Used in Invertebrates.

| Agent              | Dosage                       | Comments                                                                                                                                                                                           |
|--------------------|------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Barium sulfate     | 4 mL/15 g food <sup>21</sup> | Tarantulas, scorpions, millipedes, hissing cockroaches/contrast radiography; inject into a strawberry and feed to millipedes; inject into crickets and/or other prey for carnivorous invertebrates |
| Benzocaine topical |                              | Corals and, potentially, other aquatic invertebrates/used as                                                                                                                                       |

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| (Orabase, Colgate-Palmolive)                                               | Topically <sup>64</sup>                                                                                                    | a water-resistant paste; chemotherapeutics can be combined for topical therapy                                                                                                                                                                                                                                                               |
| Carbon, activated                                                          | 75 g/40 L tank water <sup>51</sup>                                                                                         | Removal of medications and other organics from water; usually added to filter system; discard after 2 wk; 75 g ≈ 250 cc dry volume                                                                                                                                                                                                           |
| Chlorine/chloramine neutralizer                                            | Use as directed                                                                                                            | See sodium thiosulfate                                                                                                                                                                                                                                                                                                                       |
| Diatrizoate meglumine and diatrizoate sodium (Hypaque-76, Amersham Health) | 4 mL/15 g food <sup>21</sup>                                                                                               | Tarantulas, scorpions, millipedes, hissing cockroaches/contrast radiography; combine with/inject into the food item and feed 1-3 hr prior to radiography                                                                                                                                                                                     |
| Hydrogen peroxide (3%)                                                     | 0.25 mL/L water <sup>50</sup>                                                                                              | Acute environmental hypoxia; dose from the piscine literature                                                                                                                                                                                                                                                                                |
| Iohexol                                                                    | 12 mL/kg IV                                                                                                                | Horseshoe crabs/contrast radiography                                                                                                                                                                                                                                                                                                         |
|                                                                            | 15 mL PO <sup>61</sup>                                                                                                     |                                                                                                                                                                                                                                                                                                                                              |
| Methylmethacrylate                                                         | Apply topically as needed <sup>18,56</sup>                                                                                 | Arthropods (spiders, scorpions, insects)/repair fractured exoskeleton; there are numerous references for the application of surgical adhesives, so consult the appropriate taxon-based literature                                                                                                                                            |
| Mineral oil                                                                | 1 mL/kg PO                                                                                                                 | Insects/laxative <sup>18</sup>                                                                                                                                                                                                                                                                                                               |
| Nitrifying bacteria                                                        | Use as directed for commercial products                                                                                    | Seed or improve development of biological filtration to detoxify ammonia, nitrite, and nitrate; numerous commercial preparations; do not expose products to extreme temperatures; use before expiration date                                                                                                                                 |
|                                                                            | Add material (e.g., floss, gravel) from a tank with an active biological filter and healthy fish to new tank <sup>50</sup> | Must evaluate risk of disease transmission with this technique                                                                                                                                                                                                                                                                               |
| Oxygen (100%)                                                              | Fill plastic bag with O <sub>2</sub> containing 1/3 vol of water <sup>29</sup>                                             | Acute environmental hypoxia common with transportation; close bag tightly with rubberband; keep animals in bag until normal swimming and respiratory behavior                                                                                                                                                                                |
| Sodium thiosulfate                                                         | Use as directed for chlorine/chloramine neutralizers                                                                       | Active ingredient in numerous chlorine/chloramine neutralizers; chlorine and chloramine are common additions to municipal water supplies and are toxic to many aquatic invertebrates; ammonia released by detoxification of chloramine is removed by functioning biological filter (see nitrifying bacteria) or chemical means (see zeolite) |
|                                                                            | 10 mg/L tank                                                                                                               |                                                                                                                                                                                                                                                                                                                                              |



|                                                |                                                                        |                                                                                                                                                  |
|------------------------------------------------|------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------|
|                                                | water <sup>39</sup>                                                    |                                                                                                                                                  |
|                                                | 10 g neutralizes chlorine (up to 2 mg/L) in 1000 L water <sup>39</sup> |                                                                                                                                                  |
|                                                | 100 mg/L tank water <sup>63</sup>                                      | Chlorine exposure                                                                                                                                |
| Zeolite (i.e., clinoptilite) (Ammonex, Argent) | Use as directed                                                        | Ion-exchange resin that exchanges ammonia for sodium ions; clinoptilite is an active form of zeolite; used to reduce or prevent ammonia toxicity |
|                                                | 20 g/L tank water <sup>50</sup>                                        |                                                                                                                                                  |

TABLE 1-5 Common Captive Invertebrate Taxa.<sup>a</sup>

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| <p><b>Arthropods</b></p> <p><b>Chelicerates:</b> This group includes the spiders, scorpions, and horseshoe crabs. Some common species are listed below.<sup>56,60</sup></p> <p>Chilean rosehair tarantula (<i>Grammostola spatulata</i>)<br/> Mexican fireleg tarantula (<i>Brachypelma boehmei</i>)<br/> Mexican redknee tarantula (<i>Brachypelma smithi</i>)<br/> Emperor scorpion (<i>Pandinus imperator</i>)<br/> American horseshoe crab (<i>Limulus polyphemus</i>)</p> <p><b>Myriapods (centipedes, millipedes):</b><sup>23</sup></p> <p>African banded millipedes (<i>Isulus</i> spp)<br/> Desert millipede (<i>Orthoporus</i> sp)<br/> Giant desert centipede (<i>Scolopendra heros</i>)<br/> Giant train millipedes (<i>Spirostreptida</i> spp)<br/> Madagascar fire millipedes (<i>Aphistogoniulus</i> spp)</p> <p><b>Crustaceans:</b> Decapods are a diverse group of readily recognized species including the crabs, lobsters, and shrimp. Some common examples include the banded shrimps, crayfish (numerous species), marine hermit crabs, and terrestrial hermit crabs (<i>Coenobita</i> sp).<sup>51</sup></p> <p>Sea monkeys (<i>Artemia</i> sp).<sup>51</sup></p> <p><b>Insects:</b> Insects, sometimes referred to as the phylum Hexapoda, are an immense group of over a million described species. Some common captive insects include the beetles (Order Coleoptera), butterflies and moths (Order Lepidoptera), crickets (grey crickets [<i>Acheta domestica</i>]; black prairie cricket [<i>Gryllus</i> sp]), honeybee (<i>Apis mellifera</i>), Madagascar hissing cockroach (<i>Gromphadorhina portentosa</i>), and the silkworm (<i>Bombyx mori</i>).<sup>18,23,56,70</sup></p> |
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| <b>Coelenterates</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
| <p><b>Scyphozoans (jellyfishes):</b> Although not common as pets, some individuals, and many public institutions and establishments, maintain jellyfish aquaria. Some popular species include fried egg jellies (<i>Phacellophora camtschatica</i>), moon jellies (<i>Aurelia aurita</i>), and the sea nettles (<i>Chrysaora</i> sp).<sup>64</sup></p> <p><b>Anthozoans (anemones and corals):</b> Numerous species of sea anemones and corals (hard and soft) are commonly maintained in reef aquaria. Frequently maintained soft coral groups include members of the families Alcyoniidae, Nephtheidae, and Xeniidae.<sup>38</sup> Commonly maintained scleractinian (hard coral) genera include <i>Acropora</i>, <i>Montipora</i>, and <i>Porites</i>.<sup>38</sup></p> |
| <b>Echinoderms</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
| <p>This entirely marine phylum includes five major classes:<sup>23,34</sup></p> <p><b>Asteroidea:</b> sea stars</p> <p><b>Crinoidea:</b> feather stars, sea lilies</p> <p><b>Echinoidea:</b> sand dollars, sea biscuits, sea urchins</p> <p><b>Holothuroidea:</b> sea cucumbers</p> <p><b>Ophiuroidea:</b> basket stars, brittle stars</p>                                                                                                                                                                                                                                                                                                                                                                                                                                 |
| <b>Mollusks</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
| <p><b>Gastropods (nudibranchs, sea hares, slugs, and snails):</b> This group includes a diverse array of terrestrial, freshwater, and marine species.<sup>14,27,38</sup></p> <p><b>Cephalopods (cuttlefish, nautilus, octopuses, squid):</b> This group includes a diverse group of marine species. Some species of octopus, and the chambered (<i>Nautilus pompilius</i>), are occasionally found in home aquaria.<sup>59</sup></p> <p><b>Bivalves (clams, mussels, oysters):</b> This group includes a diverse group of freshwater and marine species. One of the most common reef genera is the giant clam (<i>Tridacna</i> sp).<sup>38,46,53</sup></p>                                                                                                                 |

<sup>a</sup> This is not a comprehensive list of taxa. The reader should be aware that taxonomy is a dynamic science and taxonomists frequently assign different taxonomic levels to the same groups depending on the anatomical, genetic, and other criteria being considered.

## References

1. Allender MC, Schumacher J, Milam J, et al. Pharmacokinetics of intravascular itraconazole in the American horseshoe crab (*Limulus polyphemus*). *J Vet Pharmacol Therap*. 2007;31:83–86.
2. Aquilina B, Roberts R. A method for inducing muscle relaxation in the abalone, *Haliotis iris*. *Aquaculture*. 2000;190:403–408.
3. Avery L, Horvitz HR. 1990. Effects of starvation and neuroactive drugs on feeding in *Caenorhabditis elegans*. *J Exp Zool*. 2000;253:263–270.
4. Barron MG, Gedutis C, James MO. Pharmacokinetics of sulphadimethoxine in the lobster, *Homarus americanus*, following intrapericardial administration. *Xenobiotica*. 1988;18:269–276.
5. Battison A, MacMillans R, MacKenzie A, et al. Use of injectable potassium chloride for euthanasia of American lobsters (*Homarus americanus*). *Comp Med*. 2000;50:545–550.
6. Best JB, Morita M. Planarians as a model system for in vitro teratogenesis studies. *Teratogen Carcinog Mut*. 1982;2:277–291.
7. Blair KL, Anderson PAV. Properties of voltage-activated ionic currents in cells from the brains of the triclad flatworm *Bdelloura candida*. *J Exp Biol*. 1993;185:267–286.
8. Bodri M. Nematodes. In: Lewbart GA, ed. *Invertebrate Medicine*. 2nd ed. Ames: Wiley-Blackwell Publishing; 2012:335–354.
9. Bodri M. Turbellarians. In: Lewbart GA, ed. *Invertebrate Medicine*. 2nd ed. Ames: Wiley-Blackwell Publishing; 2012:77–93.
10. Borneman EH. Aquarium Corals. Selection, Husbandry, and Natural History. Neptune City, NJ: TFH; 2001.
11. Brown PB, White MR, Chaille J, et al. Evaluation of three anesthetic agents for crayfish (*Orconectes virilis*). *J Shellfish Res*. 1996;15:433–435.

12. Bullis RA. Care and maintenance of horseshoe crabs for use in biomedical research. In: Stolen JS, Fletcher TC, Rowley AF, et al, eds. *Techniques in Fish Immunology*, Vol 3. Fair Haven, NJ: SOS Publications; 1994:A9–A10.
13. Chair M, Nelis HJ, Leger P, et al. Accumulation of trimethoprim, sulfamethoxazole, and N-acetylsulfamethoxazole in fish and shrimp fed medicated *Artemia franciscana*. *Antimicrob Agents Chemother*. 1996;40:1649–1652.
14. Clark TR, Nossov PC, Apland JP, et al. Anesthetic agents for use in the invertebrate sea snail, *Aplysia californica*. *Contemp Top Lab Anim Sci*. 1996;35:75–79.
15. Colin ME, Duclos J, Larribau E, et al. Activité des huiles essentielles de Labiées sur *Ascosphaera apis* et traitement d'un rucher. *Apidologie*. 1989;20:221–228.
16. Cooper EL. Transplantation immunity in annelids. *Transplantation*. 1968;6:322–337.
17. Cooper JE. Invertebrate anesthesia. *Vet Clin North Am Exotic Anim Pract*. 2001;4:57–67.
18. Cooper JE. Insects. In: Lewbart GA, ed. *Invertebrate Medicine*. 2nd ed. Ames: Wiley-Blackwell Publishing; 2012:267–283.
19. Cooper JE, Mahaffey P, Applebee K. Anaesthesia of the medicinal leech (*Hirudo medicinalis*). *Vet Rec*. 1986;118:589–590.
20. Davis C, Ward W. Control of chalkbrood disease with natural products. A report for the Rural Industries Research and Development Corporation. RIRDC Publication No 03/107 RIRDC Project No DAQ-269A; 2003:1–23.
21. Davis MR, Gamble KC, Matheson JS. Diagnostic imaging in terrestrial invertebrates. Madagascar hissing cockroach (*Gromphadorhina portentosa*), desert millipede (*Orthoporus* sp), emperor scorpion (*Pandinus imperator*), Chilean rosehair tarantula (*Grammostola spatulata*), Mexican fireleg tarantula (*Brachypelma boehmei*) and Mexican redknee tarantula (*Brachypelma smithi*). *Zoo Biol*. 2008;27:109–125.

22. de Campos-Velho NMR, Lopes KAR, Hauser J. Morphometry of the eyes in regenerant of genus *Dugesia* (Platyhelminthes, Turbellaria, Dugesidae). *Braz J Biol.* 2004;64:1–9.
23. Dombrowski D, De Voe R. Emergency care of invertebrates. *Vet Clin North Am Exotic Anim Pract.* 2007;10:621–645.
24. Dorton D. The “cure” for red acro bugs. Available at <http://www.reefs.org/forums/viewtopic.php?p=439155>, Jan 18, 2011. Accessed
25. Flores DV, Salas PJI, Vedra JPS. Electroretinography and ultrastructural study of the regenerated eye of the snail, *Cryptomphallus aspera*. *J Neurobiol.* 1983;14:167–176.
26. Gardner C. Options for immobilization and killing crabs. *J Shellfish Res.* 1997;16:219–224.
27. Girdlestone D, Cruickshank SGH, Winlow W. The actions of three volatile anaesthetics on withdrawal responses of the pond-snail, *Lymnaea stagnalis* (L.). *Comp Biochem Physiol C.* 1989;92:39–43.
28. Gore SR, Harms CA, Kukanich B, et al. Enrofloxacin pharmacokinetics in the European cuttlefish, *Sepia officinalis*, after a single i.v. injection and bath administration. *J Vet Pharm Therap.* 2005;28:433–439.
29. Gratzek JB, ed. *Aquariology. The Science of Fish Health Management: Master Volume (Aquariology Series)*. Morris Plains, NJ: Tetra Press; 1994.
30. Gunkel C, Lewbart GA. Invertebrates. In: West G, Heard D, Caulkett N. *Zoo Animal and Wildlife Immobilization and Anesthesia*. Ames: Blackwell Publishing; 2007:147–158.
31. Gunkel C, Lewbart GA. Anesthesia and analgesia of invertebrates. In: Fish R, Danneman P, Brown M, et al. *Anesthesia and Analgesia in Laboratory Animals*. 2nd ed. St Louis: Elsevier; 2008:535–546.
32. Hadfield CA, Clayton LA, O’Neill KL. Milbemycin treatment of parasitic copepods on *Acropora* corals. *Proc 33rd Eastern Fish Health Workshop.* 76,

2008.

33. Harms CA. Echinoderms. In: Lewbart GA, ed. *Invertebrate Medicine*. 2nd ed. Ames: Wiley-Blackwell Publishing; 2012:365–379.
34. Harms CA, Lewbart GA, McAlarney R, et al. Surgical excision of mycotic (*Cladosporium* sp.) granulomas from the mantle of a cuttlefish (*Sepia officinalis*). *J Zoo Wildl Med*. 2006;37:524–530.
35. Heasman MP, O'Connor WA, Frazer AWJ. Induction of anaesthesia in the commercial scallop, *Pecten fumatus* Reeve. *Aquaculture*. 1995;131:231–238.
36. Hodgson G. Tetracycline reduces sedimentation damage to corals. *Mar Biol*. 1990;104:493–496.
37. Landy RB, Leibovitz L. *A preliminary study of the toxicity and therapeutic efficacy of formalin in the treatment of triclad turbellarid worm infestations in Limulus polyphemus*. Proc Annu Meet Soc Invert Pathol; 1983.
38. Lehmann DW. Reef systems. In: Lewbart GA, ed. *Invertebrate Medicine*. 2nd ed. Ames: Wiley-Blackwell Publishing; 2012:57–75.
39. Lewbart GA. Emergency and critical care of fish. *Vet Clin North Am Exotic Anim Pract*. 1998;1:233–249.
40. Lewbart G, Riser NW. Nuchal organs of the polychaete *Parapionosyllis manca* (Syllidae). *Invert Biol*. 1996;115:286–298.
41. Makino N, Shirasawa Y. Biology of long slender land planarians (Turbellaria) in Tokyo and environs. *Hydrobiologia*. 1986;132:229–232.
42. Marks DH, Cooper EL. *Aeromonas hydrophila* in the coelomic cavity of the earthworms *Lumbricus terrestris* and *Eisenia foetida*. *J Invert Pathol*. 1977;29:382–383.
43. Martins-Sousa RL, Negrao-Correa D, Bezerra FSM, et al. Anesthesia of *Biomphalaria* spp. (Mollusca, Gastropoda). sodium pentobarbital is the drug of choice. *Mem Inst Oswaldo Cruz*. 2001;96:391–392.

44. McCurley RS, Kier WM. The functional morphology of starfish tube feet. the role of a crossed-fiber helical array in movement. *Biol Bull.* 1995;188:197–209.
45. Melidone R, Mayer J. How to build an invertebrate surgery chamber. *Exotic DVM.* 2005;7.5:8–10.
46. Mills D, Tlili A, Norton J. Large-scale anesthesia of the silver-lip pearl oyster, *Pinctada maxima* Jameson. *J Shellfish Res.* 1997;16:573–574.
47. Moens T, Vincx M. On the cultivation of free-living marine and estuarine nematodes. *Helgoländer Meeresunters.* 1998;52:115–139.
48. Müller MCM, Berenzen A, Westheide W. Regeneration experiments in *Eurythoe complanata* (“Polychaeta,” Amphinomididae). reconfiguration of the nervous system and its function for regeneration. *Zoomorphology.* 2003;122:95–103.
49. Nelis HJ, Léger F, Sorgeloos P, et al. Liquid chromatographic determination of efficacy of incorporation of trimethoprim and sulfamethoxazole in brine shrimp (*Artemia* spp.) used for prophylactic chemotherapy of fish. *Antimicrob Agents Chemother.* 1991;35:2486–2489.
50. Noga EJ. Fish Disease. Diagnosis and Treatment. 2nd ed. Ames: Wiley-Blackwell; 2010.
51. Noga EJ, Hancock A, Bullis R. Crustaceans. In: Lewbart GA, ed. *Invertebrate Medicine.* 2nd ed. Ames: Wiley-Blackwell Publishing; 2012:235–254.
52. Nolan MW, Smith SA, Jones D. Pharmacokinetics of oxytetracycline in the American horseshoe crab, *Limulus polyphemus*. *J Vet Pharmacol Therap.* 2007;30:451–455.
53. Norton JH, Dashorst M, Lansky TM, et al. An evaluation of some relaxants for use with pearl oysters. *Aquaculture.* 1996;144:39–52.
54. Oswald RL. Immobilization of decapod crustaceans for experimental purposes. *J Mar Biol Assoc UK.* 1977;57:715–721.

55. Pennak RW. Turbellaria (flatworms). In: Freshwater Invertebrates of the United States. 2nd ed. New York: John Wiley and Sons; 1978:114–141.
56. Pizzi R. Spiders. In: Lewbart GA, ed. *Invertebrate Medicine*. 2nd ed. Ames: Wiley-Blackwell Publishing; 2012:187–221.
57. Reed LA, Siewicki TC, Shah C. The biopharmaceutics and oral bioavailability of two forms of oxytetracycline to the white shrimp, *Litopenaeus setiferus*. *Aquaculture*. 2006;258:42–54.
58. Reynoldson TB. The dispersal of *Urceolaria mitra* (Peritricha) epizoic on flatworms. *J Anim Ecol*. 1951;20:123–131.
59. Scimeca J. Cephalopods. In: Lewbart GA, ed. *Invertebrate Medicine*. 2nd ed. Ames: Wiley-Blackwell Publishing; 2012:113–125.
60. Smith S. Horseshoe crabs. In: Lewbart GA, ed. *Invertebrate Medicine*. 2nd ed. Ames: Wiley-Blackwell Publishing; 2012:173–185.
61. Spotswood T, Smith SA. Cardiovascular and gastrointestinal radiographic contrast studies in the horseshoe crab (*Limulus polyphemus*). *Vet Rad Ultrasound*. 2007;48:14–20.
62. Sprung J, Delbeek JC. The Reef Aquarium. A Comprehensive Guide to the Identification and Care of Tropical Marine Invertebrates. Vol 2. Coconut Grove, FL: Ricordea; 1997.
63. Stoskopf MK. Appendix V. Chemotherapeutics. Stoskopf MK, ed. *Fish Medicine*. 2nd ed. Philadelphia: WB Saunders Co; 1993:832–839.
64. Stoskopf MK. Coelenterates. In: Lewbart GA, ed. *Invertebrate Medicine*. 2nd ed. Ames: Wiley-Blackwell Publishing; 2012:21–56.
65. Tang J, Yang X, Zheng Z, et al. Pharmacokinetics and the active metabolite of enrofloxacin in Chinese mitten-handed crab (*Eriocheir sinensis*). *Aquaculture*. 2006;260:69–76.
66. Treves-Brown KM. *Applied Fish Pharmacology*. Dordrecht, The Netherlands:



67. Uno K. Pharmacokinetics of oxolinic acid and oxytetracycline in kuruma shrimp, *Penaeus japonicus*. *Aquaculture*. 2004;230:1–11.
68. Uno K, Aoki T, Kleechaya W, et al. Pharmacokinetics of oxytetracycline in black tiger shrimp, *Penaeus monodon*, and the effect of cooking on the residues. *Aquaculture*. 2006;254:24–31.
69. Van den Spiegel D, Jangoux M. Cuvierian tubules of the holothuroid *Holothuria forskali* (Echinodermata). a morphofunctional study. *Mar Biol*. 1987;96:263–275.
70. Vidal-Naquet N. Honeybees. In: Lewbart GA, ed. *Invertebrate Medicine*. 2nd ed. Ames: Wiley-Blackwell Publishing; 2012:285–321.
71. Walcourt A, Ide D. A system for the delivery of general anesthetics and other volatile agents to the fruit-fly *Drosophila melanogaster*. *J Neurosci Meth*. 1998;84:115–119.
72. White HI, Hecht T, Potgieter B. The effect of four anaesthetics on *Haliotis midae* and their suitability for application in commercial abalone culture. *Aquaculture*. 1996;140:145–151.
73. Winsor L, Johns PM, Barker GM. Terrestrial planarians (Platyhelminthes. Tricladida: Terricola) predaceous on terrestrial gastropods. Barker GM, ed. *Natural Enemies of Terrestrial Molluscs*. Cambridge: CABI Publishing; 2004:227–278.
74. Woodall AJ, Naruo H, Prince DJ, et al. Anesthetic treatment blocks synaptogenesis but not neuronal regeneration of cultured *Lymnaea* neurons. *J Neurophysiol*. 2003;90:2232–2239.

Chapter 2

Fish

Gregory A. Lewbart

TABLE 2-1 Antimicrobial and Antifungal Agents Used in Fish.<sup>a-f</sup>

| Agent       | Dosage                                                                     | Comments                                                                          |
|-------------|----------------------------------------------------------------------------|-----------------------------------------------------------------------------------|
| Acriflavine | 4 mg/L × 4h <sup>78</sup>                                                  | Rainbow trout/organic dye and antifungal agent                                    |
|             | 10 mg/L × 4h <sup>73</sup>                                                 | Channel catfish/PD                                                                |
| Amikacin    | 5 mg/kg IM<br>q12h <sup>95</sup>                                           |                                                                                   |
|             | 5 mg/kg IM<br>q72h × 3<br>treatments <sup>105</sup>                        |                                                                                   |
|             | 5 mg/kg ICe<br>q24h × 3 days,<br>then q48h × 2<br>treatments <sup>49</sup> | Koi/PD                                                                            |
| Amoxicillin | —                                                                          | Infrequently indicated in ornamental fish because few pathogens are Gram-positive |
|             | 12.5 mg/kg IM <sup>4</sup>                                                 | Atlantic salmon/PD                                                                |
|             | 25 mg/kg PO<br>q12h <sup>97</sup>                                          |                                                                                   |
|             | 40 mg/kg IV<br>q24h <sup>18</sup>                                          | Seabream/PD                                                                       |
|             | 80 mg/kg PO<br>q24h × 10<br>days <sup>18</sup>                             | Seabream/PD                                                                       |
|             | 40-80<br>mg/kg/day in<br>feed × 10 days <sup>67</sup>                      |                                                                                   |
|             | 110 mg/kg/day<br>in feed <sup>1</sup>                                      | Channel catfish/PD                                                                |
| Ampicillin  | —                                                                          | Infrequently indicated in ornamental fish because few pathogens are Gram-positive |
|             | 10 mg/kg q24h<br>IM <sup>4,102</sup>                                       |                                                                                   |
|             | 10 mg/kg q24h                                                              |                                                                                   |

|                                  |                                                         |                                                                                                                                               |
|----------------------------------|---------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------|
|                                  | IV <sup>71</sup>                                        | Striped bass                                                                                                                                  |
|                                  | 50-80 mg/kg/day in feed × 10 days <sup>67</sup>         |                                                                                                                                               |
| Azithromycin (Zithromax, Pfizer) | 30 mg/kg q24h × 14 days <sup>22</sup>                   | Chinook salmon/PD                                                                                                                             |
|                                  | 40 mg/kg ICe <sup>23</sup>                              | Chinook salmon/PD                                                                                                                             |
| Aztreonam (Azactam, Squibb)      | 100 mg/kg IM, ICe q48h × 7 treatments <sup>80</sup>     | Koi/ <i>Aeromonas salmonicida</i> ; used by hobbyists                                                                                         |
| Benzalkonium chloride            | 0.5 mg/L long-term <sup>102</sup>                       | Quaternary amine with broad disinfection properties                                                                                           |
|                                  | 10 mg/L for 10 min <sup>102</sup>                       |                                                                                                                                               |
| Bronopol (Pyceze, Novartis)      | 15-50 mg/L × 30-60 min bath <sup>75,105</sup>           | For mycotic infections (eggs and fish); eggs may require the higher dose                                                                      |
| Ceftazidime (Fortaz, Pfizer)     | 22 mg/kg IM, ICe q72-96h × 3-5 treatments <sup>80</sup> | Cephalosporin with good activity against Gram-negative bacteria (e.g., <i>Pseudomonas</i> )                                                   |
| Chloramine-T                     | 2.5-20 mg/L as immersion treatment <sup>15,102</sup>    | Disinfectant; used to control bacterial gill disease and some ectoparasites; dosage and duration varies widely with species and water quality |
|                                  | 20 mg/L as immersion × 4 hr <sup>64</sup>               | Rainbow trout, striped bass, yellow perch/PD                                                                                                  |
| Chloramphenicol                  | —                                                       | Florfenicol may be a better alternative than chloramphenicol (risk to humans)                                                                 |
|                                  | 40-182 mg/kg q24h ICe <sup>54</sup>                     | Carp/PD                                                                                                                                       |
|                                  | 50 mg/kg PO, IM once, then 25 mg/kg q24h <sup>97</sup>  |                                                                                                                                               |
|                                  | 50 mg/kg PO q24h <sup>13</sup>                          | Rainbow trout/PD                                                                                                                              |
| Ciprofloxacin                    | 15 mg/kg IM, IV <sup>69</sup>                           | Carp, African catfish, rainbow trout/PD                                                                                                       |
| Conazole (Prochloraz)            | 10 mg/kg PO q24h <sup>12</sup>                          | Rainbow trout/antifungal                                                                                                                      |
| Difloxacin                       | 10 mg/kg PO                                             | Atlantic salmon/PD; plasma levels were higher in                                                                                              |

|                                          |                                                                  |                                                                                                                                   |
|------------------------------------------|------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------|
|                                          | q24h <sup>21</sup><br>20 mg/kg PO<br>q24h × 3 days <sup>19</sup> | marine fish compared with freshwater fish<br>Goldfish/PD                                                                          |
| Enrofloxacin (Baytril, Bayer)            | —                                                                | For a review of quinolones used in fishes see<br>Samuelsen, 2006 <sup>84</sup>                                                    |
|                                          | 2.5 mg/kg IV<br>q24h <sup>17</sup>                               | Seabream/PD; no ciprofloxacin detected                                                                                            |
|                                          | 5 mg/kg PO, IM,<br>ICe q24h <sup>97</sup>                        | Red pacu/PD <sup>62</sup>                                                                                                         |
|                                          | 5-10 mg/kg PO<br>q24h <sup>102</sup>                             |                                                                                                                                   |
|                                          | 5-10 mg/kg IM,<br>ICe q48h <sup>62</sup> × 7<br>treatments       |                                                                                                                                   |
|                                          | 10 mg/kg PO<br>q24h <sup>17,84</sup>                             | Atlantic salmon, seabream/PD; no ciprofloxacin<br>detected                                                                        |
|                                          | 10 mg/kg PO,<br>IV <sup>52</sup>                                 | Korean catfish/PD; ciprofloxacin detected                                                                                         |
|                                          | 10 mg/kg ICe<br>q96h × 4<br>treatments <sup>61</sup>             | Koi/PD (21°C, 70°F)                                                                                                               |
|                                          | 10 mg/kg PO in<br>feed q24h <sup>57,67,94</sup>                  | Atlantic salmon/PD                                                                                                                |
|                                          | 0.1% feed × 10-<br>14 days                                       | Oral or injectable form can be used                                                                                               |
|                                          | 2.5-5 mg/L × 5<br>hr bath q24h <sup>62</sup> ×<br>5-7 days       | Red pacu/PD; change 50-75% of water between<br>treatments                                                                         |
| Erythromycin                             | —                                                                | Commonly sold as tank treatment for aquarium<br>fish; not recommended because of toxicity to<br>nitrifying bacteria <sup>67</sup> |
|                                          | 75 mg/kg PO<br>q24h × 7 days <sup>14</sup>                       | Barramundi/successful treatment of <i>Streptococcus</i><br><i>iniae</i>                                                           |
|                                          | 100 mg/kg PO,<br>IM q24h × 7-21<br>days <sup>97,102</sup>        |                                                                                                                                   |
|                                          | 100-200 mg/kg<br>PO q24h × 21<br>days <sup>65</sup>              | Salmonids/to control <i>Renibacterium</i><br><i>salmoninarum</i>                                                                  |
| Florfenicol (Nuflor, Schering<br>Plough) | 5-20 mg/kg PO<br>q24h <sup>44</sup>                              | Atlantic salmon/PD                                                                                                                |

|                                            |                                                                              |                                                                                                                                                                                                                                                                                                                                               |
|--------------------------------------------|------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                                            | 10 mg/kg IM<br>q24h <sup><a href="#">110,111</a></sup>                       | Koi/PD                                                                                                                                                                                                                                                                                                                                        |
|                                            | 10-20 mg/kg PO<br>q24h <sup><a href="#">85,88</a></sup>                      | Cod/PD                                                                                                                                                                                                                                                                                                                                        |
|                                            | × 10 days                                                                    |                                                                                                                                                                                                                                                                                                                                               |
|                                            | 25-50 mg/kg PO<br>q24h <sup><a href="#">110,111</a></sup>                    | Koi/PD                                                                                                                                                                                                                                                                                                                                        |
|                                            | 40 mg/kg IM <sup><a href="#">112</a></sup>                                   | White-spotted bamboo shark/PD                                                                                                                                                                                                                                                                                                                 |
|                                            | 40-50 mg/kg<br>PO, IM, ICe<br>q12-24h <sup><a href="#">60,97</a></sup>       | Red pacu/PD <sup><a href="#">60</a></sup>                                                                                                                                                                                                                                                                                                     |
|                                            | 100 mg/kg IM<br>q24h <sup><a href="#">110,111</a></sup>                      | Gourami/PD                                                                                                                                                                                                                                                                                                                                    |
| Flumequine (Apoquin aqualtes,<br>Alpharma) | —                                                                            | Quinolone; Gram-negative bacteria; freshwater fish at pH 6.8-7.2; decreased uptake in hard water; increase dose for marine fish                                                                                                                                                                                                               |
|                                            | 10 mg/kg PO<br>q48h <sup><a href="#">34</a></sup>                            | Cod, goldsinny wrasse/PD                                                                                                                                                                                                                                                                                                                      |
|                                            | 12-25 mg/kg<br>PO, ICe, IV<br>q24h <sup><a href="#">86</a></sup>             | Atlantic halibut/PD                                                                                                                                                                                                                                                                                                                           |
|                                            | 25 mg/kg ICe<br>q24h <sup><a href="#">87</a></sup>                           | Corkwing wrasse/PD                                                                                                                                                                                                                                                                                                                            |
|                                            | 25-50 mg/kg PO<br>q24h <sup><a href="#">82</a></sup>                         | Atlantic salmon                                                                                                                                                                                                                                                                                                                               |
|                                            | 30 mg/kg IM,<br>ICe <sup><a href="#">67</a></sup>                            | High antibiotic levels for several days when given IM                                                                                                                                                                                                                                                                                         |
|                                            | 50-100 mg/L × 3<br>hr bath <sup><a href="#">67</a></sup>                     |                                                                                                                                                                                                                                                                                                                                               |
|                                            | 10 mg/kg q24h<br>in feed × 10<br>days <sup><a href="#">67</a></sup>          |                                                                                                                                                                                                                                                                                                                                               |
| Formalin                                   | All doses based<br>on volumes of<br>100% formalin<br>(= 37%<br>formaldehyde) | Mycotic infections on eggs; do not treat within 24 hr of hatching; caution: carcinogenic; do not use if highly toxic white precipitates of paraformaldehyde are present; some fish are very sensitive; test on small number first, monitor fish for respiratory distress and pale color; increased toxicity in soft, acidic water and at high |
|                                            | 0.23 mL/L bath<br>up to 60 min <sup><a href="#">67</a></sup>                 |                                                                                                                                                                                                                                                                                                                                               |
|                                            | 1 mL/38 L as                                                                 |                                                                                                                                                                                                                                                                                                                                               |

|                                                  |                                                                              |                                                                                                                       |
|--------------------------------------------------|------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------|
|                                                  | 12-24 hr bath followed by 30-70% water change, may be repeated <sup>28</sup> | temperature; treat with vigorous aeration because of oxygen depletion; toxic to plants                                |
|                                                  | 1-2 mL/L bath, up to 15 min <sup>67</sup>                                    | For eggs only                                                                                                         |
|                                                  | 25 mg/L (9.3 mg formaldehyde/L) bath for 144 hr <sup>108</sup>               | Striped bass                                                                                                          |
| Furazolidone                                     | —                                                                            | Nitrofurantoin; caution: carcinogenic; toxic to scaleless fish; absorbed from water; drug inactivated in bright light |
|                                                  | 1 mg/kg PO, IV q24h <sup>72</sup>                                            | Channel catfish                                                                                                       |
|                                                  | 30 mg/kg PO <sup>109</sup>                                                   | Nile tilapia                                                                                                          |
|                                                  | 67.5 mg/kg PO q12h × 10 days <sup>55</sup>                                   | Rainbow trout/PD; at 14°C (57°F), half-life ≈ 30 days and residue present at 40 days post 10-day treatment            |
|                                                  | 25-35 mg/kg q24h in feed for 20 days <sup>42</sup>                           | Some salmonids/not approved for fish intended for human consumption in the United States                              |
|                                                  | 50-100 mg/kg q24h in feed × 10-15 days <sup>67</sup>                         |                                                                                                                       |
|                                                  | 1-10 mg/L tank water for ≥ 24 hr <sup>67</sup>                               |                                                                                                                       |
| Gentamicin                                       | 1 mg/kg IM, ICe q24h <sup>91</sup>                                           | Channel catfish/PD                                                                                                    |
|                                                  | 2 mg/kg IM, then 1 mg/kg IM at 8 and 72 hr <sup>98</sup>                     | Brown shark/PD                                                                                                        |
|                                                  | 2.5 mg/kg IM q72h <sup>58</sup>                                              | Nephrotoxic; substantial risk in species for which dosages have not been determined <sup>77</sup>                     |
|                                                  | 3.5 mg/kg IM q24h <sup>50</sup>                                              | Goldfish, toadfish/PD                                                                                                 |
| Iodine, potentiated (Betadine, Purdue Frederick) | Topical to wound, rinse immediately <sup>67</sup>                            | Do not use solutions combined with detergent (e.g., Betadine scrub)                                                   |

|                                        |                                                                      |                                                                                                                                                                                                                                                                                      |
|----------------------------------------|----------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                                        | 20-100 mg/L for 10 min <sup><a href="#">102</a></sup>                | For disinfecting eggs (available iodine)                                                                                                                                                                                                                                             |
| Itraconazole                           | 1-5 mg/kg q24h in feed q1-7d <sup><a href="#">97</a></sup>           | Systemic mycoses                                                                                                                                                                                                                                                                     |
| Kanamycin sulfate (Kantrex, Adothecon) | 20 mg/kg ICe q3d × 5 treatments <sup><a href="#">67</a></sup>        | Toxic to some fish                                                                                                                                                                                                                                                                   |
|                                        | 50 mg/kg q24h in feed <sup><a href="#">67</a></sup>                  |                                                                                                                                                                                                                                                                                      |
|                                        | 40-640 mg/L × 2 hr bath <sup><a href="#">26</a></sup>                | Channel catfish                                                                                                                                                                                                                                                                      |
|                                        | 50-100 mg/L q72h × 3 treatments <sup><a href="#">67</a></sup>        | Change 50-75% of water between treatments; absorbed from water                                                                                                                                                                                                                       |
| Ketoconazole                           | 2.5-10 mg/kg PO, IM, ICe <sup><a href="#">97</a></sup>               | Systemic mycoses                                                                                                                                                                                                                                                                     |
| Malachite green (zinc-free)            | —                                                                    | Freshwater fish/mycotic infections; caution: mutagenic, teratogenic; toxic to some fish species and to fry; increased toxicity at higher temperatures and lower pH; stains objects, especially plastic; toxic to plants; not approved for use on fish intended for human consumption |
|                                        | 0.1 mg/L tank water q3d × 3 treatments <sup><a href="#">67</a></sup> | Remove residual chemical with activated carbon after final treatment                                                                                                                                                                                                                 |
|                                        | 0.25 mg/L × 15 min q24h <sup><a href="#">106</a></sup>               | Fungal control on fish eggs                                                                                                                                                                                                                                                          |
|                                        | 0.5 mg/L × 1 hr bath <sup><a href="#">67</a></sup>                   | Freshwater fish eggs                                                                                                                                                                                                                                                                 |
|                                        | 1 mg/L × 30-60 min bath <sup><a href="#">67</a></sup>                | Use 2 mg/L if pH is high                                                                                                                                                                                                                                                             |
|                                        | 1 mg/L × 1 hr <sup><a href="#">102</a></sup>                         | Fungal control on fish eggs                                                                                                                                                                                                                                                          |
|                                        | 2 mg/L × 15 min q24h <sup><a href="#">102</a></sup>                  | Fungal control on fish eggs                                                                                                                                                                                                                                                          |
|                                        | 10 mg/L × 10-30 min bath <sup><a href="#">67</a></sup>               | Freshwater fish eggs                                                                                                                                                                                                                                                                 |
|                                        | 50-60 mg/L × 10-30 sec bath <sup><a href="#">67</a></sup>            |                                                                                                                                                                                                                                                                                      |
|                                        | 100 mg/L topical to skin                                             |                                                                                                                                                                                                                                                                                      |

|                                               |                                                          |                                                                                                                                                                                                        |
|-----------------------------------------------|----------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                                               | lesions <sup>67</sup>                                    |                                                                                                                                                                                                        |
| Methylene blue                                | 2 mg/L tank water q48h, up to 3 treatments <sup>67</sup> | Preventing infections of freshwater eggs; toxic to nitrifying bacteria and to plants; stains many objects                                                                                              |
| Miconazole (Monistat, Janssen)                | 10-20 mg/kg PO, IM, ICe <sup>97</sup>                    | Systemic mycoses                                                                                                                                                                                       |
| Nalidixic acid<br>(Neg Gram, Sanofi Winthrop) | 5 mg/kg PO, IM q24h <sup>97</sup>                        | Quinolone; Gram-negative bacteria<br><br>Rainbow trout/PD                                                                                                                                              |
|                                               | 5 mg/kg PO, IV q24h <sup>48</sup>                        |                                                                                                                                                                                                        |
|                                               | 20 mg/kg PO q24h <sup>102</sup>                          |                                                                                                                                                                                                        |
|                                               | 13 mg/L × 1-4 hr bath, repeat prn <sup>67</sup>          |                                                                                                                                                                                                        |
| Neomycin                                      | 66 mg/L tank water q3d, up to 3 treatments <sup>67</sup> | Commonly sold as tank treatment for aquarium fish; toxic to nitrifying bacteria; keep fish densities low                                                                                               |
| Nifurpirinol                                  | —                                                        | Nitrofurantoin; caution: carcinogenic; toxic to scaleless fish; absorbed from water; drug inactivated in bright light                                                                                  |
|                                               | 0.45-0.9 mg/kg PO q24h × 5 days <sup>67</sup>            |                                                                                                                                                                                                        |
|                                               | 4-10 mg/kg in feed q12h × 5 days <sup>68</sup>           |                                                                                                                                                                                                        |
|                                               | 0.1 mg/L tank water q24h × 3-5 days <sup>67</sup>        |                                                                                                                                                                                                        |
|                                               | 1-2 mg/L × 5 min-6 hr bath <sup>67</sup>                 |                                                                                                                                                                                                        |
| Nitrofurazone                                 | —                                                        | Nitrofurantoin; caution: carcinogenic; toxic to scaleless fish; absorbed from water; drug inactivated in bright light; water soluble formulations preferred; change 50-75% of water between treatments |
|                                               |                                                          |                                                                                                                                                                                                        |
|                                               | 2-5 mg/L tank water q24h × 5-                            |                                                                                                                                                                                                        |



|                 |                                                   |                                                               |
|-----------------|---------------------------------------------------|---------------------------------------------------------------|
|                 | 10 days <sup>105</sup>                            |                                                               |
|                 | 50 mg/L × 3 hr <sup>9</sup>                       | Seabream/no residues were found in muscle following treatment |
|                 | 100 mg/L × 30 min bath <sup>67</sup>              |                                                               |
|                 | 100 mg/L × 6 hr <sup>9</sup>                      | Tilapia/no residues were found in muscle following treatment  |
| Oxolinic acid   | —                                                 | Quinolone; Gram-negative bacteria                             |
|                 | 5-25 mg/kg PO q24h <sup>97</sup>                  |                                                               |
|                 | 10 mg/kg q24h PO <sup>102</sup>                   | Freshwater species/PD in many species                         |
|                 | 25 mg/kg ICe q24h <sup>87</sup>                   | Corkwing wrasse/PD                                            |
|                 | 25-50 mg/kg q24h PO <sup>102</sup>                | Marine species                                                |
|                 | 50 mg/kg q24h × 5 days PO <sup>10,11</sup>        | Rainbow trout/PD                                              |
|                 | 10 mg/kg q24h in feed × 10 days <sup>67</sup>     |                                                               |
|                 | 3-10 mg/L tank water × 24 hr <sup>67</sup>        |                                                               |
|                 | 25 mg/L × 15 min bath q12h × 3 days <sup>67</sup> | Decreased uptake in hard water; better uptake in pH <6.9      |
| Oxytetracycline | 3 mg/kg IV q24h <sup>20</sup>                     | Red pacu/PD                                                   |
|                 | 7 mg/kg IM q24h <sup>20</sup>                     | Red pacu/PD                                                   |
|                 | 10 mg/kg IM q24h <sup>97</sup>                    | Produces high levels for several days when given IM           |
|                 | 20 mg/kg ICe <sup>102</sup>                       | Some salmonids                                                |
|                 | 20 mg/kg PO q8h <sup>97</sup>                     |                                                               |
|                 | 25-50 mg/kg IM, ICe <sup>67</sup>                 |                                                               |
|                 | 60 mg/kg IM q7d <sup>30</sup>                     | Carp/PD                                                       |

|                                 |                                                         |                                                                                                                                                                                                                                                                                                                     |
|---------------------------------|---------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                                 | 70 mg/kg PO<br>q24h × 10-14<br>days <sup>104</sup>      |                                                                                                                                                                                                                                                                                                                     |
|                                 | 82.8 mg/kg PO ×<br>10 days <sup>8</sup>                 | Walleye pike, tilapia, hybrid striped bass, summer<br>flounder/PD                                                                                                                                                                                                                                                   |
|                                 | 100 mg/kg IM<br>q24h <sup>79</sup>                      | Tench/PD                                                                                                                                                                                                                                                                                                            |
|                                 | 10-100 mg/L<br>tank water <sup>67</sup>                 | Higher doses in hard water; if fish still sick,<br>retreat on day 3 after 50% water change; light<br>sensitive, so keep tank covered to prevent photo-<br>inactivation; drug turns dark brown when<br>decomposing: change 50% of water immediately;<br>change 50-75% of water between treatments                    |
|                                 | 7 mg/g feed<br>q24h × 10<br>days <sup>104</sup>         |                                                                                                                                                                                                                                                                                                                     |
|                                 | 55-83 mg/kg<br>q24h in feed ×<br>10 days <sup>67</sup>  |                                                                                                                                                                                                                                                                                                                     |
|                                 | 75 mg/kg PO<br>q24h in feed ×<br>10 days <sup>102</sup> |                                                                                                                                                                                                                                                                                                                     |
|                                 | 10-50 mg/L × 1<br>hr bath <sup>67</sup>                 | Surface bacterial infections; yellow-brown foam<br>may develop in treatment water                                                                                                                                                                                                                                   |
| Potassium permanganate          | 2 mg/L as an<br>indefinite<br>bath <sup>105</sup>       | Heavily organic systems may require a higher<br>dose; test efficacy by adding the appropriate<br>amount of KMnO <sub>4</sub> to a small amount of system<br>water (without fish); red color should remain for<br>at least 4 hr (if not, then KMnO <sub>4</sub> should be added<br>until the 4-hr test is completed) |
|                                 | 5 mg/L × 30-60<br>min bath <sup>67</sup>                | Freshwater fish/skin and gill bacterial infections;<br>toxic in water with high pH; do not mix with<br>formalin; can be toxic in goldfish <sup>95</sup>                                                                                                                                                             |
|                                 | 1000 mg/L × 10-<br>40 sec bath <sup>67</sup>            |                                                                                                                                                                                                                                                                                                                     |
| Sarafloxacin (Saraflox, Abbott) | 10-14 mg/kg PO<br>q24h × 10<br>days <sup>97</sup>       | Fluoroquinolone                                                                                                                                                                                                                                                                                                     |
|                                 | 10 mg/kg PO<br>q24h <sup>102</sup>                      | Marine Atlantic salmon                                                                                                                                                                                                                                                                                              |
|                                 | 10 mg/kg PO<br>q24h × 5 days <sup>27</sup>              | Channel catfish                                                                                                                                                                                                                                                                                                     |
|                                 |                                                         |                                                                                                                                                                                                                                                                                                                     |

|                                                                              |                                                                                     |                                                                                                                                                                                                                                                                                 |
|------------------------------------------------------------------------------|-------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Silver sulfadiazine cream (Silvadene, Marion Merrill Dow)                    | Topical q12h <sup>58</sup>                                                          | External bacterial infection; keep lesion out of water 30-60 sec after application; keep gills submerged                                                                                                                                                                        |
| Sulfadimethoxine/ormetoprim (Romet, Hoffman-LaRoche)                         | 50 mg/kg/day in feed × 5 days <sup>67</sup><br>Medicated brine shrimp <sup>67</sup> | Available as a powder to add to feed and as medicated feed<br>Place brine shrimp nauplii (larvae) in 3 mg/L seawater for 4 hr, rinse in seawater with brine shrimp net, then feed immediately to fish; may also work with adult brine shrimp and other live feeds <sup>67</sup> |
| Thiamphenicol                                                                | 15 and 30 mg/kg PO <sup>45</sup>                                                    | Sea bass/PD; drug was not detected in plasma or tissues at either dose on day 7; recommended withdrawal times of 5 and 6 days, respectively                                                                                                                                     |
| Tobramycin                                                                   | 2.5 mg/kg IM, then 1 mg/kg IM q4d <sup>98</sup>                                     | Brown shark/PD                                                                                                                                                                                                                                                                  |
| Trimethoprim/sulfamethoxazole                                                | 30 mg/kg PO q24h × 10-14 days <sup>67</sup>                                         | Change 50-75% of water between treatments                                                                                                                                                                                                                                       |
|                                                                              | 20 mg/L × 5-12 hr bath q24h × 5-7 days <sup>67</sup>                                |                                                                                                                                                                                                                                                                                 |
|                                                                              | 0.2% feed × 10-14 days <sup>67</sup>                                                |                                                                                                                                                                                                                                                                                 |
| Triple antibiotic ointment (polymyxin B sulfate/bacitracin/neomycin sulfate) | Topical q12h <sup>58</sup>                                                          | External bacterial infection; keep lesion out of water 30-60 sec following application; keep gills submerged                                                                                                                                                                    |

<sup>a</sup> Not to be used in fish for human consumption.

<sup>b</sup> Preferable to treat a single fish of a species (biotest) to determine toxicity.

<sup>c</sup> Tank treatment: When treating the fishes' resident aquarium, disconnect activated carbon filtration to prevent drug removal. Many drugs adversely affect the nitrifying bacteria, so water quality should be monitored closely (especially ammonia and nitrite concentrations). Always keep water well aerated and monitor fish closely. Perform water changes and reconnect filtration to remove residual drug following treatment. Discard carbon following drug removal.<sup>59</sup>

<sup>d</sup> Bath (immersion) treatment: Remove fish from resident aquarium and place in container with known volume of water and concentration of therapeutic agent. Watch closely for signs of toxicity (e.g., listing and dyspnea). Always keep water well aerated.

<sup>e</sup> Species of fish, temperature, and water quality parameters can influence the pharmacodynamics of many drugs, especially antimicrobials.

<sup>f</sup> For more information, refer to the web site by Reimschuessel et al.<sup>78</sup> This is a comprehensive and informative resource for many drugs and other compounds used with aquatic animals.

TABLE 2-2 Antiparasitic Agents Used in Fish.<sup>a-d</sup>

| Agent                                                                    | Dosage                                                                                                            | Comments                                                                                                                                                                     |
|--------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Acetic acid, glacial                                                     | 1-2 mL/L ×<br>30-45 sec<br>bath <sup>67,105</sup>                                                                 | Monogenean trematodes, crustacean ectoparasites; safe for goldfish; may be toxic to smaller tropical fish                                                                    |
| Albendazole                                                              | 5 mg/kg PO<br>once <sup>66</sup>                                                                                  | Atlantic salmon/PD                                                                                                                                                           |
|                                                                          | 10 mg/kg PO<br>once <sup>92</sup>                                                                                 | Atlantic salmon, rainbow trout, tilapia/PD                                                                                                                                   |
|                                                                          | 10-50 mg/L ×<br>2-6 hr <sup>90</sup>                                                                              | Sticklebacks/treating <i>Glugea anomala</i> infection                                                                                                                        |
| Chloramine-T                                                             | —                                                                                                                 | See <a href="#">Table 2-1</a>                                                                                                                                                |
| Chloroquine<br>diphosphate                                               | 50 mg/kg PO<br>once <sup>63</sup><br><br>10 mg/L tank<br>water, once <sup>67</sup>                                | Red drum<br><br><i>Amyloodinium ocellatum</i> ; monitor for 21 days, retreat prn; use activated carbon to remove drug if no relapse                                          |
| Closantel (50<br>mg/mL)/mebendazole<br>(75 mg/mL)<br>(Supaverm, Janssen) | 1 mL/400 L<br>once; may<br>repeat in 3-7<br>days<br>following a<br>water change<br>if<br>necessary <sup>105</sup> | Very safe and effective in koi for external monogeneans; reported to be highly toxic to goldfish and medaka; used in the United Kingdom to kill digenean trematodes of sheep |
|                                                                          |                                                                                                                   |                                                                                                                                                                              |

|                                         |                                                                                              |                                                                                                                                                                                                                                                             |
|-----------------------------------------|----------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Copper sulfate                          | —                                                                                            | Marine fish/protozoan, trematode ectoparasites; copper levels must be assessed with a commercial kit, and adjusted as needed; toxic to gill tissue; immunosuppressive; extremely toxic to invertebrates and many plants; copper removed by activated carbon |
|                                         | 0.012 and 0.094 mg/L bath for 28 days <sup>31</sup>                                          | European eel                                                                                                                                                                                                                                                |
|                                         | 0.02 mg/L bath × 65 or 72 hr <sup>32,33</sup>                                                | Rainbow trout                                                                                                                                                                                                                                               |
|                                         | 0.1-0.2 mg/L <sup>102</sup>                                                                  | Use higher dose in hard water                                                                                                                                                                                                                               |
|                                         | Maintain free ion levels at 0.15-0.2 mg/L tank water, until therapeutic effect <sup>67</sup> |                                                                                                                                                                                                                                                             |
|                                         | Maintain copper levels at 0.2 mg/L tank water × 14-21 days <sup>104</sup>                    | Citrated copper sulfate; prepare stock solution of 1 mg/mL (3 g CuSO <sub>4</sub> · 5H <sub>2</sub> O and 2 g citric acid monohydrate in 750 mL distilled water)                                                                                            |
|                                         | Maintain free ion levels at 0.25-1 mg/L × 24-48 hr bath <sup>36</sup>                        |                                                                                                                                                                                                                                                             |
|                                         | 100 mg/L × 1-5 min bath <sup>7</sup>                                                         | Prepare stock solution of 1 mg/mL (1 g CuSO <sub>4</sub> · 5H <sub>2</sub> O in 250 mL distilled water)                                                                                                                                                     |
| Di-flubenzuron (Dimilin, Union Carbide) | 0.01 mg/L tank water × 48 hr q6d × 3 treatments <sup>95</sup>                                | Crustacean ectoparasites; inhibits chitin synthesis; drug persists in water long-term; marketed for control of terrestrial insects; may need EPA license for use in the United States                                                                       |
| Dimethyl phosphonate                    | —                                                                                            | See trichlorfon                                                                                                                                                                                                                                             |
| Dimetridazole                           | 28 mg/kg in feed q24h × 10 days <sup>76</sup>                                                | Rainbow trout/ <i>Ichthyophthirius multifiliis</i> ; not available in United States                                                                                                                                                                         |
| Enamectin (Slice,                       | 50 µg/kg q24h                                                                                | Atlantic salmon/PD; an avermectin compound used to control                                                                                                                                                                                                  |

|                  |                                                                                      |                                                                                                                                                                                                                                                                                                                                                                            |
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| Schering Plough) | × 7 days PO <sup>89</sup>                                                            | sea lice ( <i>Lepeophtheirus salmonis</i> , <i>Caligus elongatus</i> , <i>C. teres</i> , and <i>C. rogercressyi</i> )                                                                                                                                                                                                                                                      |
| Fenbendazole     | 1 mg/kg IV <sup>16</sup>                                                             | Channel catfish                                                                                                                                                                                                                                                                                                                                                            |
|                  | 5 mg/kg PO × 1 dose <sup>53</sup>                                                    | Channel catfish                                                                                                                                                                                                                                                                                                                                                            |
|                  | 6 mg/kg q24h PO <sup>47</sup>                                                        | Rainbow trout                                                                                                                                                                                                                                                                                                                                                              |
|                  | 50 mg/kg PO q24h × 2 days, repeat in 14 days <sup>104</sup>                          |                                                                                                                                                                                                                                                                                                                                                                            |
|                  | 0.2% in feed × 3 days, repeat in 14-21 days <sup>57</sup>                            |                                                                                                                                                                                                                                                                                                                                                                            |
|                  | 40 mg/kg in feed q4d × 2 treatments <sup>102</sup>                                   | Carp/ <i>Bothriocephalus acheilognathi</i>                                                                                                                                                                                                                                                                                                                                 |
|                  | 1.5 mg/L × 12-hr bath <sup>47</sup>                                                  | Rainbow trout                                                                                                                                                                                                                                                                                                                                                              |
|                  | 2 mg/L tank water q7d × 3 treatments <sup>67</sup>                                   | Nonencysted gastrointestinal nematodes                                                                                                                                                                                                                                                                                                                                     |
|                  | 2.5 mg/g feed × 2-3 days, repeat in 14 days <sup>104</sup>                           |                                                                                                                                                                                                                                                                                                                                                                            |
|                  | Medicated brine shrimp, feed 2 consecutive days and repeat in 14 days <sup>104</sup> | Place live brine shrimp in 400 mg fenbendazole per 100 mL water × 15-20 min, immediately before feeding to fish                                                                                                                                                                                                                                                            |
| Formalin         | —                                                                                    | Formalin combination follows                                                                                                                                                                                                                                                                                                                                               |
|                  | All doses based on volumes of 100% formalin (= 37% formaldehyde)                     | Protozoan, trematode, crustacean ectoparasites; caution: carcinogenic; do not use if highly toxic white precipitates are present; some fish are very sensitive: test on small number first, monitor for piping and pale color; increased toxicity in soft, acidic water and at high temperature; treat with vigorous aeration because of oxygen depletion; toxic to plants |
|                  |                                                                                      |                                                                                                                                                                                                                                                                                                                                                                            |

|                                        |                                                                              |                                                                                                                                                                                                                             |
|----------------------------------------|------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                                        | 0.015-0.025 mL/L tank water <sup>67</sup>                                    | For <i>Ichthyophthirius</i> , use 0.025 mL/L tank water q48h × 3 treatments; change up to 50% of water on alternate days                                                                                                    |
|                                        | 0.125-0.25 mL/L, up to 60 min bath, repeat q24h × 2-3 days prn <sup>67</sup> | When using maximum dose, treat q3d                                                                                                                                                                                          |
|                                        | 0.4 mL/L up to 1 hr bath q3d, up to 3 treatments <sup>95</sup>               | Soft water                                                                                                                                                                                                                  |
|                                        | 0.5 mL/L up to 1 hr bath q3d, up to 3 treatments <sup>95</sup>               | Hard water                                                                                                                                                                                                                  |
| Formalin (F)/malachite green (M)       | (F) 0.025 mL/L + (M) 0.1 mg/L tank water q48h × 3 treatments <sup>67</sup>   | Combination synergistic for <i>Ichthyophthirius</i> ; change up to 50% water on alternate days; several premixed commercial products available; malachite green should never be used on fish intended for human consumption |
| Freshwater                             | 3-15 min bath, repeat q7d prn <sup>67</sup>                                  | Marine fish/ectoparasites; aerate well; monitor closely; some small fish are sensitive                                                                                                                                      |
|                                        | 4-5 min bath <sup>57</sup>                                                   |                                                                                                                                                                                                                             |
| Hydrogen peroxide (3%)                 | 1-1.5 mg/L × 20 min bath <sup>101</sup>                                      | Atlantic salmon/sea lice                                                                                                                                                                                                    |
|                                        | 17.5 mL/L × 4-10 min bath, once <sup>36</sup>                                | Ectoparasites; monitor closely; may be harmful to smaller fish                                                                                                                                                              |
| Ivermectin                             | —                                                                            | Do not use; neurologic signs and death at therapeutic doses; <sup>36,102</sup> toxic to many environmental invertebrates <sup>102</sup>                                                                                     |
| Levamisole (Levasole, Schering Plough) | 0.5 mg/kg ICe <sup>51</sup><br>10 mg/kg PO q7d × 3 treatments <sup>36</sup>  | Rainbow trout/immunostimulant                                                                                                                                                                                               |
|                                        | 11 mg/kg IM q7d × 2                                                          |                                                                                                                                                                                                                             |

|                               |                                                               |                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
|-------------------------------|---------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                               | treatments <sup>36</sup>                                      |                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
|                               | 1 mg/L × 24 hr bath <sup>99</sup>                             | Eels/swimbladder nematodes                                                                                                                                                                                                                                                                                                                                                                                                                             |
|                               | 1-2 mg/L × 24 hr bath <sup>36</sup>                           | Internal nematodes, especially larval                                                                                                                                                                                                                                                                                                                                                                                                                  |
|                               | 50 mg/L × 2 hr bath <sup>36</sup>                             |                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
|                               | 4 g/kg feed q7d × 3 treatments <sup>36</sup>                  | External trematodes                                                                                                                                                                                                                                                                                                                                                                                                                                    |
| Lufenuron (Program, Novartis) | 0.13 mg/L prn <sup>80,105</sup>                               | Control of crustacean ectoparasites                                                                                                                                                                                                                                                                                                                                                                                                                    |
| Malachite green               | —<br><br>0.1 mg/L tank water q3d × 3 treatments <sup>67</sup> | See formalin for combination                                                                                                                                                                                                                                                                                                                                                                                                                           |
|                               | 1 mg/L × 30-60 min bath <sup>67</sup>                         | Use 2 mg/L if pH high                                                                                                                                                                                                                                                                                                                                                                                                                                  |
|                               | 50-60 mg/L × 10-30 sec bath <sup>67</sup>                     |                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
|                               | 100 mg/L topical to skin lesions <sup>67</sup>                | Freshwater fish/protozoan ectoparasites; prepare stock solution of 3.7 mg/mL (1.4 g malachite green in 380 mL water); caution: mutagenic, teratogenic; toxic to some fish species (e.g., tetras) and fry; increased toxicity at higher temperatures and lower pH; toxic to plants; stains objects, especially plastic; remove residual chemical with activated carbon after last tank treatment; not to be used on fish intended for human consumption |
| Mebendazole                   | 20 mg/kg PO q7d × 3 treatments <sup>97</sup>                  | Gastrointestinal nematodes; do not administer to brood fish: embryotoxic and teratogenic                                                                                                                                                                                                                                                                                                                                                               |
|                               | 1 mg/L × 24 hr bath <sup>36,46</sup>                          | Monogenean trematodes                                                                                                                                                                                                                                                                                                                                                                                                                                  |
|                               | 1 mg/L × 72 hr bath <sup>5</sup>                              | European eels/branchial monogeneans ( <i>Pseudodactylogyrus bini</i> and <i>P. anguillae</i> )                                                                                                                                                                                                                                                                                                                                                         |
|                               | 10-50 mg/L for 2-6 hr immersion <sup>90</sup>                 | Sticklebacks/ <i>Glugea anomala</i>                                                                                                                                                                                                                                                                                                                                                                                                                    |



|                        |                                                                            |                                                                                                                                                                                                  |
|------------------------|----------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                        | 100 mg/L × 10 min-2 hr bath <sup><a href="#">36</a></sup>                  | Monogenean trematodes                                                                                                                                                                            |
| Methylene blue         | 1-3 mg/L tank water <sup><a href="#">67</a></sup>                          | Freshwater fish/ectoparasites; not recommended because of poor efficacy; toxic to nitrifying bacteria; stains objects; toxic to plants                                                           |
| Metronidazole          | 25 mg/kg q24h in feed × 5-10 days <sup><a href="#">67</a></sup>            | Equivalent to 0.25% in feed (250 mg/100 g food) at 1% BW/day                                                                                                                                     |
|                        | 50 mg/kg PO q24h × 5 days <sup><a href="#">36</a></sup>                    |                                                                                                                                                                                                  |
|                        | 100 mg/kg q24h in feed × 3 days <sup><a href="#">67</a></sup>              | Equivalent to 1% in feed (1 g/100 g food) at 1% BW/day                                                                                                                                           |
|                        | 6.6 mg/L tank water q24h × 3 days <sup><a href="#">67</a></sup>            | <i>Spironucleus (Hexamita)</i> and other internal flagellates; some external flagellates; poorly soluble in water: dissolve before adding to water or feed; change water between tank treatments |
|                        | 25 mg/L tank water q48h × 3 treatments <sup><a href="#">67</a></sup>       |                                                                                                                                                                                                  |
|                        | 6.25-18 mg/g feed × 5 days <sup><a href="#">104</a></sup>                  |                                                                                                                                                                                                  |
|                        | Medicated brine shrimp, daily × 5 treatments <sup><a href="#">49</a></sup> | Place live brine shrimp in 625 mg metronidazole per 100 mL water × 15-20 min immediately before feeding to fish                                                                                  |
| Niclosamide            | 0.055 mg/L × 24 hr bath <sup><a href="#">43</a></sup>                      | Rainbow trout/lampricide                                                                                                                                                                         |
| Piperazine             | 10 mg/kg q24h in feed × 3 days <sup><a href="#">67</a></sup>               | Nonencysted gastrointestinal nematodes; equivalent to 0.1% in feed at 1% BW/day                                                                                                                  |
| Potassium permanganate | 5 mg/L × 30-60 min bath <sup><a href="#">67</a></sup>                      | Freshwater fish/protozoan, crustacean ectoparasites; toxic in water with high pH; do not mix with formalin; can be toxic in goldfish <sup><a href="#">95</a></sup>                               |
|                        | 100 mg/L × 5-10 min bath <sup><a href="#">67</a></sup>                     |                                                                                                                                                                                                  |
|                        | 1 g/L × 10-40 sec bath <sup><a href="#">67</a></sup>                       |                                                                                                                                                                                                  |
| Praziquantel           | 5 mg/kg PO q24h × 3                                                        |                                                                                                                                                                                                  |

|                           |                                                                                                |                                                                                                                                                                                                                                                                                                                               |
|---------------------------|------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                           | treatments <sup>102</sup><br>5 mg/kg PO in<br>feed q7d, up<br>to 3<br>treatments <sup>97</sup> |                                                                                                                                                                                                                                                                                                                               |
|                           | 5 mg/kg PO,<br>ICe, repeat in<br>14-21 days <sup>57</sup>                                      | Cestodes, some internal digenean trematodes; could be<br>administered in feed                                                                                                                                                                                                                                                 |
|                           | 50 mg/kg PO<br>once <sup>67</sup>                                                              | Adult cestodes; gavage or give 0.5% in feed at 1% BW/day                                                                                                                                                                                                                                                                      |
|                           | 2 mg/L × 2-4<br>hr <sup>74</sup>                                                               | Metacercaria                                                                                                                                                                                                                                                                                                                  |
|                           | 2-10 mg/L up<br>to 4 hr bath <sup>104</sup>                                                    | Monitor closely for lethargy, incoordination, loss of<br>equilibrium                                                                                                                                                                                                                                                          |
|                           | 5-10 mg/L ×<br>3-6 hr bath,<br>repeat in 7<br>days <sup>57</sup>                               | Monogenean trematode ectoparasites, cestodes; aerate water<br>well; some marine fish sensitive; may be toxic to <i>Corydoras</i><br>catfish                                                                                                                                                                                   |
|                           | 5-12 mg/kg<br>feed × 3<br>days <sup>104</sup>                                                  |                                                                                                                                                                                                                                                                                                                               |
| Pyrantel pamoate          | 10 mg/kg in<br>feed, once <sup>97</sup>                                                        | Gastric nematodes                                                                                                                                                                                                                                                                                                             |
| Salt (sodium<br>chloride) | —                                                                                              | Freshwater fish/protozoan, trematode ectoparasites; seawater<br>or artificial sea salts preferred; seawater is normally 30-35<br>g/L; use non-iodized table/rock salts; some anticaking agents<br>in solar salts are highly toxic; species sensitivity is highly<br>variable (some catfish sensitive); may be toxic to plants |
|                           | 1-5 g/L tank<br>water,<br>indefinitely <sup>67</sup>                                           | Prophylaxis or treatment of ectoparasites                                                                                                                                                                                                                                                                                     |
|                           | 3 g/L <sup>102</sup>                                                                           | Supportive care                                                                                                                                                                                                                                                                                                               |
|                           | 10-30 g/L up<br>to 30 min<br>bath <sup>67</sup>                                                | With salt-sensitive or weak fish, use lower dosage and repeat<br>in 24 hr                                                                                                                                                                                                                                                     |
|                           | 30 g/L for 10<br>min <sup>102</sup>                                                            | Fish >100 g only                                                                                                                                                                                                                                                                                                              |
|                           | 30-35 g/L × 4-<br>5 min bath <sup>57</sup>                                                     | Safe for goldfish and koi in most cases                                                                                                                                                                                                                                                                                       |
| Thiabendazole             | 10-25 mg/kg<br>in feed, repeat                                                                 | Gastric nematodes; anorexia may be seen (more severe at                                                                                                                                                                                                                                                                       |

|                                    |                                                                                                       |                                                                                                                                                                                                                                                                                               |
|------------------------------------|-------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                                    | in 10 days <sup>97</sup>                                                                              | higher doses), generally resolves within 2-4 days                                                                                                                                                                                                                                             |
|                                    | 66 mg/kg PO, once <sup>97</sup>                                                                       |                                                                                                                                                                                                                                                                                               |
| Trichlorfon (dimethyl phosphonate) | —                                                                                                     | Caution: organophosphate, neurotoxic, avoid inhalation and skin contact; aerate water well; especially toxic to larval fish and tetras; liquid form marketed for cattle is convenient to dispense                                                                                             |
|                                    | 0.25 mg/L tank water; <sup>67</sup> 96 hr bath at this concentration in channel catfish <sup>78</sup> | Freshwater fish/use 0.5 mg/L tank water if >27°C (80°F); treat q3d × 2 treatments for <i>Dactylogyrus</i> and other oviparous monogeneans; treat q7d × 4 treatments for anchor worms ( <i>Argulus</i> ); single treatment will usually suffice for other copepods, other monogeneans, leeches |
|                                    | 0.5 mg/L tank water q10d × 3 treatments <sup>57</sup>                                                 | Crustacean ectoparasites; change 20-30% of water 24-48 hr following each treatment                                                                                                                                                                                                            |
|                                    | 0.5-1 mg/L tank water <sup>67</sup>                                                                   | Marine fish/treat q3d × 2 treatments for oviparous monogeneans; use 1 mg/L q48h × 3 treatments for turbellarians; single treatment will usually suffice for copepods (except sea lice), other monogeneans, leeches                                                                            |

<sup>a</sup> Not to be used in fish for human consumption.

<sup>b</sup> Preferable to treat single fish of a species to determine toxicity.

<sup>c</sup> Tank treatment: when treating the fishes’ resident aquarium, disconnect activated carbon filtration to prevent drug removal; many drugs adversely affect the nitrifying bacteria, so water quality should be monitored closely (especially ammonia and nitrite concentrations); always keep water well aerated and monitor fish closely; perform water changes and reconnect filtration to remove residual drug following treatment; discard carbon following drug removal.<sup>59</sup>

<sup>d</sup> Bath (immersion) treatment: remove fish from resident aquarium and place in container with known volume of water and concentration of therapeutic agent; watch closely for signs of toxicity, e.g., listing and dyspnea; always keep water well aerated.

TABLE 2-3 Chemical Restraint/Anesthetic/Analgesic Agents Used in Fish.<sup>a-c</sup>

| Agent                                 | Dosage                                                                           | Comments                                                                                                                                                                                                                                                                                                                                                                         |
|---------------------------------------|----------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Atipamezole<br>(Antisedan,<br>Pfizer) | 0.2 mg/kg<br>IM <sup><a href="#">25</a></sup>                                    | Reversal agent (alpha-2 antagonist) for medetomidine                                                                                                                                                                                                                                                                                                                             |
| Benzocaine                            | —                                                                                | Not sold as fish anesthetic in United States; available from chemical supply companies; do not use topical anesthetic products marketed for mammals; prepare stock solution in ethanol (benzocaine is poorly soluble in water); store in dark bottle at room temperature                                                                                                         |
|                                       | 15-40 mg/L<br>bath <sup><a href="#">67</a></sup>                                 | Transport sedation                                                                                                                                                                                                                                                                                                                                                               |
|                                       | 50-500 mg/L<br>bath <sup><a href="#">67</a></sup>                                | Anesthesia                                                                                                                                                                                                                                                                                                                                                                       |
|                                       | 70 mg/L for 5<br>min then 35<br>mg/L for 30<br>min <sup><a href="#">78</a></sup> | Channel catfish                                                                                                                                                                                                                                                                                                                                                                  |
|                                       | 1 g/L spray <sup><a href="#">67</a></sup>                                        | Large fish/anesthesia; spray onto gills with an aerosol pump sprayer                                                                                                                                                                                                                                                                                                             |
| Butorphanol                           | 0.05-0.1<br>mg/kg IM <sup><a href="#">97</a></sup>                               | Postoperative analgesia                                                                                                                                                                                                                                                                                                                                                          |
|                                       | 0.4 mg/kg<br>IM <sup><a href="#">38,40</a></sup>                                 | Koi/postoperative analgesia                                                                                                                                                                                                                                                                                                                                                      |
| Carbon dioxide                        | —                                                                                | Euthanasia: bubble gas through water until respiration stops >10 min; other agents preferred <sup><a href="#">67</a></sup>                                                                                                                                                                                                                                                       |
| Clove oil<br>(eugenol)                | 17-25<br>mg/L <sup><a href="#">102</a></sup>                                     | Aqui-S, a compound mixture of eugenol and polysorbate 80 (for solubility); lower doses (6 mg/L) will produce sedation without general anesthesia <sup><a href="#">102</a></sup>                                                                                                                                                                                                  |
|                                       | 40-120 mg/L<br>bath <sup><a href="#">57</a></sup>                                | Stock solution: 100 mg/mL of eugenol by diluting 1 part clove oil with 9 parts 95% ethanol (eugenol is poorly soluble in water); over-the-counter preparation (pure) available at most pharmacies contains approximately 1 g eugenol per mL of clove oil; recovery may be prolonged; use lower end of this range to start; many bony fishes readily anesthetized with 25-50 mg/L |
| Dexmedetomidine                       | —                                                                                | See medetomidine for comments                                                                                                                                                                                                                                                                                                                                                    |
| Ethanol                               | 1-1.5% bath <sup><a href="#">37</a></sup>                                        | Anesthetic levels difficult to control, resulting in overdose; not recommended                                                                                                                                                                                                                                                                                                   |
|                                       | >3% bath <sup><a href="#">37</a></sup>                                           | Euthanasia; other agents preferred                                                                                                                                                                                                                                                                                                                                               |
| Etomidate                             | 1-4 mg/L <sup><a href="#">102</a></sup>                                          | Lower doses should be used with striped bass and related species <sup><a href="#">102</a></sup>                                                                                                                                                                                                                                                                                  |
| Eugenol                               | —                                                                                | See clove oil                                                                                                                                                                                                                                                                                                                                                                    |
|                                       |                                                                                  |                                                                                                                                                                                                                                                                                                                                                                                  |

|                                                |                                                                   |                                                                                                                                                                                                                 |
|------------------------------------------------|-------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Isoflurane                                     | 0.5-2 mL/L bath or vaporize then bubble in water <sup>37</sup>    | Anesthetic levels difficult to control, resulting in overdose; not recommended                                                                                                                                  |
| Ketamine                                       | —                                                                 | Ketamine combination follows                                                                                                                                                                                    |
|                                                | 66-88 mg/kg IM <sup>97</sup>                                      | Immobilization for short procedures; complete recovery can take >1 hr                                                                                                                                           |
| Ketamine (K)/medetomidine (M)                  | (K) 1-2 mg/kg + (M) 0.05-0.1 mg/kg IM <sup>37</sup>               | Immobilization; reverse (M) with atipamezole (0.2 mg/kg IM)                                                                                                                                                     |
| Lidocaine                                      | —                                                                 | Local anesthetic; use cautiously in small fish; do not exceed 1-2 mg/kg total dose <sup>38</sup>                                                                                                                |
| Medetomidine                                   | 0.03-0.07 mg/kg IV <sup>25</sup>                                  | See ketamine for combination; medetomidine is off-market, but is available through selected compounding services                                                                                                |
| Metomidate (Marinil, Wildlife Pharmaceuticals) | —                                                                 | Not currently available in United States; stock solution: 10 g/L; store stock in dark container; some fish turn very dark transiently; gouramis may be sensitive; contraindicated in cichlids in water of pH <5 |
|                                                | 0.06-0.2 mg/L water <sup>96</sup>                                 | Transport sedation                                                                                                                                                                                              |
|                                                | 0.5-1 mg/L water <sup>37</sup>                                    | Light sedation                                                                                                                                                                                                  |
|                                                | 1-10 mg/L bath induction; 0.1-1 mg/L maintenance <sup>96</sup>    | Freshwater fish/anesthesia                                                                                                                                                                                      |
|                                                | 2.5-5 mg/L water <sup>37</sup>                                    | Heavy sedation                                                                                                                                                                                                  |
|                                                | 2.5-5 mg/L bath induction; 0.2-0.3 mg/L maintenance <sup>96</sup> | Marine fish/anesthesia                                                                                                                                                                                          |
|                                                | 3 mg/kg IV <sup>35</sup>                                          | Atlantic halibut, turbot/PD                                                                                                                                                                                     |
|                                                | 5-10 mg/L bath <sup>37</sup>                                      | Anesthesia; some species require 10-30 mg/L bath                                                                                                                                                                |
|                                                | 7 mg/kg PO <sup>35</sup>                                          | Turbot/PD                                                                                                                                                                                                       |
|                                                | 9 mg/L bath for 5 min <sup>35</sup>                               | Atlantic halibut, turbot/PD                                                                                                                                                                                     |

|                                                       |                                                                                                                                                                                                               |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
|-------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| MS-222 (Finquel, Argent)                              | —                                                                                                                                                                                                             | See tricaine methanesulfonate                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
| Pentobarbital                                         | 60 mg/kg<br>ICe <sup>67</sup>                                                                                                                                                                                 | Euthanasia                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
| Phenoxyethanol                                        | 0.1-0.5<br>mL/L <sup>102</sup>                                                                                                                                                                                |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
|                                                       | 0.6 mL/L <sup>102</sup>                                                                                                                                                                                       | Carp/surgery                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| Propofol                                              | 3.5-7.5 mg/kg<br>IV <sup>25</sup>                                                                                                                                                                             | Gulf of Mexico sturgeon                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
| Quinaldine sulfate<br>(Current Research Laboratories) | 25 mg/L <sup>102</sup>                                                                                                                                                                                        | Channel catfish, salmonids/do not use with largemouth bass; not recommended for long surgical procedures <sup>102</sup>                                                                                                                                                                                                                                                                                                                                                                                                          |
|                                                       | 50-100 mg/L<br>bath<br>induction; 15-<br>60 mg/L<br>maintenance <sup>37</sup>                                                                                                                                 | Anesthesia; not sold as fish anesthetic in United States; stock solution: 10 g/L, buffer the acidity by adding sodium bicarbonate to saturation; store stock in dark container; shelf-life of stock extended by refrigeration or freezing; aerate water to prevent hypoxemia; drug not metabolized, excreted unchanged; euthanasia: keep in solution >10 min after respiration stops                                                                                                                                             |
| Sodium bicarbonate                                    | 30 g/L bath <sup>67</sup>                                                                                                                                                                                     | Euthanasia; generates CO <sub>2</sub> ; use when other agents unavailable; keep fish in solution >10 min after respiration stops; generally not recommended; not an AVMA-approved method of euthanasia                                                                                                                                                                                                                                                                                                                           |
| Sodium bicarbonate tablets (Alka-Seltzer, Bayer)      | 2-4 tablets/L<br>bath <sup>28</sup>                                                                                                                                                                           | Euthanasia; generates CO <sub>2</sub> ; use when other agents unavailable; keep fish in solution >10 min after respiration stops; generally not recommended; not an AVMA-approved method of euthanasia                                                                                                                                                                                                                                                                                                                           |
| Tricaine methanesulfonate (MS-222; Finquel, Argent)   | 15-50 mg/L<br>water <sup>37</sup><br><br>50-100 mg/L<br>bath<br>induction; 50-<br>60 mg/L<br>maintenance <sup>96</sup><br><br>100-200 mg/L<br>bath<br>induction; 50-<br>100 mg/L<br>maintenance <sup>37</sup> | Sedation<br><br>Anesthesia; stock solution: 10 g/L, buffer the acidity by adding sodium bicarbonate at 10 g/L or to saturation (unbuffered solution may cause some ectoparasites to leave fish) <sup>7</sup> store stock in dark container; shelf-life of stock extended by refrigeration or freezing; stock that develops an oily film should be discarded; aerate water to prevent hypoxemia; narrower margin of safety in young fish, and soft, warm water; euthanasia: keep fish in solution >20 min after respiration stops |
|                                                       | 1 g/L spray <sup>67</sup>                                                                                                                                                                                     | Large fish/anesthesia; spray onto gills with an aerosol pump sprayer                                                                                                                                                                                                                                                                                                                                                                                                                                                             |

<sup>a</sup> Not to be used in fish for human consumption.

<sup>b</sup> Preferable to treat single fish of a species to determine toxicity.

<sup>c</sup> Aerate water during anesthetic procedures; dissolved oxygen concentrations should be maintained between 6 and 10 mg/L.

TABLE 2-4 Miscellaneous Agents Used in Fish.<sup>a-c</sup>

| Agent                              | Dosage                                             | Comments                                                                                                                                                                                                                                                                        |
|------------------------------------|----------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Atropine                           | 0.1 mg/kg IM, IV, ICe <sup>95</sup>                | Organophosphate, chlorinated hydrocarbon toxicity                                                                                                                                                                                                                               |
| Becaplermin (Regranex, Systagenix) | Topically as a thin layer for 3 min <sup>24</sup>  | Ocean surgeonfish/light debridement of the head and lateral line erosion (HLLE) lesions is recommended prior to treatment; multiple treatments are not warranted but fish should be returned to a habitat without predisposing factors to HLLE                                  |
| Carbon, activated                  | 75 g/40 L tank water <sup>67</sup>                 | Removal of medications and other organics from water; usually added to filter system; discard after 2 wk; 75 g $\approx$ 250 cc dry volume                                                                                                                                      |
| Carp pituitary extract             | 0.75 mg/kg IM <sup>102</sup>                       | Female fish (<2 kg)                                                                                                                                                                                                                                                             |
|                                    | 1-1.5 mg/kg IM <sup>102</sup>                      | Male fish                                                                                                                                                                                                                                                                       |
|                                    | 1.5 mg/kg IM <sup>102</sup>                        | Female fish (2-5 kg)                                                                                                                                                                                                                                                            |
|                                    | 2.5-3 mg/kg IM <sup>102</sup>                      | Female fish (>5 kg)                                                                                                                                                                                                                                                             |
|                                    | 5 mg/kg IM, repeat in 6 hr <sup>97</sup>           | Dose when combined with human chorionic gonadotropin (20 U/kg); hormone to stimulate release of eggs (may be given in 2 doses, 24 hr apart; the first “preparatory” dose $\leq$ 10% of the total dose); does not cause eggs to mature; do not administer unless eggs are mature |
| Chlorine/chloramine neutralizer    | Use as directed                                    | See sodium thiosulfate                                                                                                                                                                                                                                                          |
| Dexamethasone                      | 1-2 mg/kg IM, ICe <sup>97</sup>                    | Adjunct to treatment of shock, trauma, chronic stress syndromes                                                                                                                                                                                                                 |
|                                    | 2 mg/kg IV, ICe q12h <sup>57</sup>                 | Chlorine toxicity; may improve prognosis                                                                                                                                                                                                                                        |
| Doxapram                           | 5 mg/kg IV, ICe <sup>95</sup>                      | Respiratory depression                                                                                                                                                                                                                                                          |
| Epinephrine (1:1000)               | 0.2-0.5 mL IM, IV, ICe, intracardiac <sup>95</sup> | Cardiac arrest                                                                                                                                                                                                                                                                  |
|                                    | 2-5 mg/kg IM q12-                                  | Diuretic; ascites, generalized edema; of questionable value                                                                                                                                                                                                                     |



|                                      |                                                                                                                                            |                                                                                                                                                                                                                                                                                |
|--------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Furosemide                           | 72h <sup><a href="#">97</a></sup>                                                                                                          | since fish lack a loop of Henle                                                                                                                                                                                                                                                |
| Glucans<br>(Macrogard,<br>Mackzymal) | 2-10 mg/kg<br>ICe <sup><a href="#">81,102</a></sup><br><br>2 g/kg in feed × 7<br>days <sup><a href="#">93</a></sup>                        | Polysaccharides; immunostimulant<br><br>Tested with positive results in rainbow trout                                                                                                                                                                                          |
| Haloperidol                          | 0.5 mg/kg IM <sup><a href="#">97</a></sup>                                                                                                 | Dopamine blocking agent; use with LRH-A to stimulate release of eggs                                                                                                                                                                                                           |
| Human chorionic gonadotropin (hCG)   | 20 U/kg IM, repeat in 6 hr <sup><a href="#">97</a></sup>                                                                                   | Dose when combined with carp pituitary extract (5 mg/kg)                                                                                                                                                                                                                       |
|                                      | 30 U/kg IM, repeat in 6 hr <sup><a href="#">97</a></sup>                                                                                   | Hormone to stimulate release of eggs; does not cause eggs to mature: do not administer unless eggs are mature                                                                                                                                                                  |
|                                      | 800-1000 U/kg IM q8h <sup><a href="#">107</a></sup>                                                                                        | Carp                                                                                                                                                                                                                                                                           |
| Hydrocortisone                       | 1-4 mg/kg IM, ICe <sup><a href="#">97</a></sup>                                                                                            | Adjunct to treatment of shock, trauma, chronic stress syndromes                                                                                                                                                                                                                |
| Hydrogen peroxide (3%)               | 0.25 mL/L water <sup><a href="#">67</a></sup>                                                                                              | Acute environmental hypoxia; see oxygen                                                                                                                                                                                                                                        |
| LRH-A                                | 2 µg/kg IM, then 8 µg/kg 6 hr later <sup><a href="#">97</a></sup>                                                                          | Synthetic luteinizing releasing hormone analog; stimulates release of eggs; does not cause eggs to mature: do not administer unless eggs are mature; in species that do not respond to LRH-A alone, administer with haloperidol or reserpine with the first injection of LRH-A |
| Methyltestosterone                   | 30 mg/kg PO q24h × 2 or 4 days <sup><a href="#">78</a></sup>                                                                               | Rainbow trout/PD                                                                                                                                                                                                                                                               |
| Nitrifying bacteria                  | Use as directed for commercial products                                                                                                    | Seed or improve development of biological filtration to detoxify ammonia, nitrite, and nitrate; numerous commercial preparations; do not expose products to extreme temperatures; use before expiration date                                                                   |
|                                      | Add material (e.g., floss, gravel) from a tank with an active biological filter and healthy fish to new tank <sup><a href="#">67</a></sup> | Must evaluate risk of disease transmission with this technique                                                                                                                                                                                                                 |
| Oxygen (100%)                        | Fill plastic bag with O <sub>2</sub> containing ⅓ vol of water <sup><a href="#">57</a></sup>                                               | Acute environmental hypoxia common with transportation; close bag tightly with rubber band; keep fish in bag until normal swimming and respiratory behavior                                                                                                                    |
| Reserpine                            | 50 mg/kg IM <sup><a href="#">97</a></sup>                                                                                                  | Dopamine blocking agent; use with LRH-A to stimulate release of eggs                                                                                                                                                                                                           |



|                                                |                                                                                             |                                                                                                                                                                                                                                                                                                                        |
|------------------------------------------------|---------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Salt (sodium chloride)                         | 1-3 g/L tank water <sup>56</sup>                                                            | Freshwater fish/prevention of stress-induced mortality; seawater or artificial sea salts preferred; use non-iodized table/rock salts; some anticaking agents in solar salts are highly toxic; highly variable species sensitivity to salt (some catfish sensitive); may be toxic to plants                             |
|                                                | 3-5 g/L tank water <sup>67</sup>                                                            |                                                                                                                                                                                                                                                                                                                        |
|                                                | Add chloride to produce at least a 6:1 ratio (w/w) of Cl:NO <sub>2</sub> ions <sup>67</sup> | Treatment of nitrite toxicity; amount of Cl <sup>-</sup> needed (mg/L) = [6 × (NO <sub>2</sub> <sup>-</sup> in water)] - (Cl <sup>-</sup> in water); table/rock salt = 60% Cl, artificial sea salts = 55% Cl                                                                                                           |
| Sodium thiosulfate                             | Use as directed for chlorine/chloramine neutralizers                                        | Active ingredient in numerous chlorine/chloramine neutralizers; chlorine and chloramine are common additions to municipal water supplies and are toxic to fish; ammonia released by detoxification of chloramine is removed by functioning biological filter (see nitrifying bacteria) or chemical means (see zeolite) |
|                                                | 10 mg/L tank water <sup>57</sup>                                                            |                                                                                                                                                                                                                                                                                                                        |
|                                                | 100 mg/L tank water <sup>95</sup>                                                           |                                                                                                                                                                                                                                                                                                                        |
|                                                | 10 g neutralizes chlorine (up to 2 mg/L) from 1000 L water <sup>57</sup>                    |                                                                                                                                                                                                                                                                                                                        |
| Zeolite (i.e., clinoptilite) (Ammonex, Argent) | Use as directed                                                                             | Ion-exchange resin that exchanges ammonia for sodium ions; clinoptilite is an active form of zeolite; used to reduce or prevent ammonia toxicity                                                                                                                                                                       |
|                                                | 20 g/L tank water <sup>67</sup>                                                             |                                                                                                                                                                                                                                                                                                                        |

<sup>a</sup> Not to be used in fish for human consumption.

<sup>b</sup> Preferable to treat single fish of a species to determine toxicity.

<sup>c</sup> Bath treatment: remove fish from resident aquarium and place in container with known volume of water and concentration of therapeutic agent; watch closely for signs of toxicity, e.g., listing and dyspnea; always keep water well aerated.

TABLE 2-5 Hematologic and Serum Biochemical Values of Fish.<sup>a</sup>

| Measurements              | Goldfish ( <i>Carassius auratus</i> ) <sup>3,29</sup> | Koi ( <i>Cyprinus carpio</i> ) <sup>29,70,103</sup> |
|---------------------------|-------------------------------------------------------|-----------------------------------------------------|
| <b>Hematology</b>         |                                                       |                                                     |
| PCV (%)                   | 26 ± 1                                                | 35 (24-43)                                          |
| RBC (10 <sup>6</sup> /μL) | 1.5 ± 0.1                                             | 1.61-1.91                                           |

|                           |                |                |
|---------------------------|----------------|----------------|
| Hgb (g/dL)                | 9.1 ± 0.4      | 6.32-7.55      |
| MCV (fL)                  | —              | 166.3-190      |
| MCH (pg)                  | —              | 37.7-42.7      |
| MCHC (g/dL)               | —              | 20.4-22.9      |
| WBC (10 <sup>3</sup> /μL) | —              | 19.8-28.1      |
| Heterophils (%)           | 29 ± 3         | 7.96-13.89     |
| Lymphocytes (%)           | 70 ± 5         | 74.5-83.7      |
| Monocytes (%)             | 1 ± 0.1        | 2.3-3.4        |
| Azurophils (%)            | —              | —              |
| Eosinophils (%)           | —              | —              |
| Basophils (%)             | —              | 3.5-5.6        |
| <b>Chemistries</b>        |                |                |
| ALP (U/L)                 | —              | 12 (4-56)      |
| ALT (U/L)                 | 106 (97-115)   | 31 (9-98)      |
| Anion gap                 | —              | 17 (14-23)     |
| AST (U/L)                 | 908 (806-1010) | 121 (40-381)   |
| Bicarbonate (mmol/L)      | —              | 6 (3-8)        |
| Bile acids (μmol/L)       | —              | 1 (0-6)        |
| BUN (mg/dL)               | 28             | 2 (0.2-5)      |
| Calcium (mg/dL)           | —              | 8.7 (7.8-11.4) |
| Chloride (mEq/L)          | —              | 114 (108-119)  |
| Cholesterol (mg/dL)       | —              | 149 (94-282)   |
| Creatine kinase (U/L)     | —              | 4123 (80-9014) |
| Creatinine (mg/dL)        | —              | —              |
| Glucose (mg/dL)           | 73 (64-82)     | 37 (22-65)     |
| GGT (U/L)                 | —              | 1 (0-6)        |
| LDH (U/L)                 | —              | 359 (41-1675)  |
| Magnesium (mEq/L)         | —              | —              |
| Osmolality (mOsm/kg)      | —              | —              |
| Phosphorus (mg/dL)        | —              | 6.1 (3.5-7.7)  |
| Potassium (mEq/L)         | —              | 1.4 (0-2.9)    |
| Protein, total (g/dL)     | —              | 3.4 (2.7-4.3)  |

|                           |                                                                                           |                                                                                              |
|---------------------------|-------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------|
| Albumin (g/dL)            | —                                                                                         | 2 (1.4-2.7)                                                                                  |
| Globulin (g/dL)           | —                                                                                         | 0.9 (0.6-1.1)                                                                                |
| A:G (ratio)               | —                                                                                         | 1.1 (0.8-1.6)                                                                                |
| Sodium (mEq/L)            | —                                                                                         | 133 (110-143)                                                                                |
| Total bilirubin (mg/dL)   | —                                                                                         | 0.5 (0.2-2)                                                                                  |
| Uric acid (mg/dL)         | —                                                                                         | 0.1 (0-0.5)                                                                                  |
| Measurements              | Striped bass ( <i>Morone saxatilis</i> ) <sup><a href="#">41</a>,<a href="#">68</a></sup> | Palmetto bass ( <i>Morone saxatilis</i> x <i>M. chrysops</i> ) <sup><a href="#">68</a></sup> |
| Hematology                |                                                                                           |                                                                                              |
| PCV (%)                   | 42 (34-28)                                                                                | —                                                                                            |
| RBC (10 <sup>6</sup> /μL) | —                                                                                         | —                                                                                            |
| Hgb (g/dL)                | —                                                                                         | —                                                                                            |
| MCV (fL)                  | —                                                                                         | —                                                                                            |
| MCH (pg)                  | —                                                                                         | —                                                                                            |
| MCHC (g/dL)               | —                                                                                         | —                                                                                            |
| WBC (10 <sup>3</sup> /μL) | —                                                                                         | —                                                                                            |
| Heterophils (%)           | —                                                                                         | —                                                                                            |
| Lymphocytes (%)           | —                                                                                         | —                                                                                            |
| Monocytes (%)             | —                                                                                         | —                                                                                            |
| Azurophils (%)            | —                                                                                         | —                                                                                            |
| Eosinophils (%)           | —                                                                                         | —                                                                                            |
| Basophils (%)             | —                                                                                         | —                                                                                            |
| Chemistries               |                                                                                           |                                                                                              |
| ALP (U/L)                 | —                                                                                         | —                                                                                            |
| ALT (U/L)                 | —                                                                                         | —                                                                                            |
| Anion gap                 | 29 ± 5                                                                                    | 24 ± 1                                                                                       |
| AST (U/L)                 | 23 ± 6                                                                                    | 45 ± 21                                                                                      |
| Bicarbonate (mmol/L)      | —                                                                                         | —                                                                                            |
| BUN (mg/dL)               | —                                                                                         | —                                                                                            |
| Calcium (mg/dL)           | 10.6 ± 0.1                                                                                | 11.1 ± 0.2                                                                                   |
| Chloride (mEq/L)          | 143 ± 2                                                                                   | 144 ± 2                                                                                      |
| Cholesterol (mg/dL)       | —                                                                                         | —                                                                                            |
| Creatine kinase (U/L)     | —                                                                                         | —                                                                                            |
| Creatinine (mg/dL)        | 0.5 ± 0                                                                                   | 0.3 ± 0                                                                                      |

|                                |                                                                  |                                                                   |
|--------------------------------|------------------------------------------------------------------|-------------------------------------------------------------------|
| Glucose (mg/dL)                | 100 ± 28                                                         | 118 ± 10                                                          |
| LDH (U/L)                      | 221 ± 92                                                         | 164 ± 54                                                          |
| Magnesium (mEq/L)              | —                                                                | —                                                                 |
| Osmolality (mOsm/kg)           | 348 ± 2                                                          | 356 ± 2                                                           |
| Phosphorus (mg/dL)             | 10 ± 0.3                                                         | 9.8 ± 0.2                                                         |
| Potassium (mEq/L)              | 3.9 ± 0.1                                                        | 3.3 ± 0.2                                                         |
| Protein, total (g/dL)          | 3.8 ± 0.1                                                        | 4.6 ± 0.1                                                         |
| Albumin (g/dL)                 | 1.1 ± 0                                                          | 1.3 ± 0                                                           |
| Globulin (g/dL)                | —                                                                | —                                                                 |
| A:G (ratio)                    | 0.4 ± 0                                                          | 0.4 ± 0                                                           |
| Sodium (mEq/L)                 | 181 ± 4                                                          | 174 ± 2                                                           |
| Total CO <sub>2</sub> (mmol/L) | 9.5 ± 1                                                          | 10.7 ± 0.9                                                        |
| Urea nitrogen (mg/dL)          | —                                                                | —                                                                 |
| Uric acid (mg/dL)              | —                                                                | —                                                                 |
| Measurement                    | <b>Red pacu (<i>Piaractus brachypomum</i>)</b> <sup>83,100</sup> | <b>Southern stingray (<i>Dasyatis americana</i>)</b> <sup>6</sup> |

|                           |                  |            |
|---------------------------|------------------|------------|
| <b>Hematology</b>         |                  |            |
| PCV (%)                   | 26 (22-32)       | 22 (15-25) |
| RBC (10 <sup>6</sup> /μL) | 1.7 (1.2-2.9)    | —          |
| Hgb (g/dL)                | —                | —          |
| MCV (fL)                  | —                | —          |
| MCH (pg)                  | —                | —          |
| MCHC (g/dL)               | —                | —          |
| WBC (10 <sup>3</sup> /μL) | 33.5 (13.6-52.3) | 22.1-42.2  |
| Heterophils (%)           | 5.2 (0.3-36.7)   | —          |
| Lymphocytes (%)           | 84 (53-96)       | —          |
| Monocytes (%)             | 4 (0.8-11.2)     | —          |
| Azurophils (%)            | —                | —          |
| Eosinophils (%)           | 0.3 (0.3-0.7)    | —          |
| Basophils (%)             | —                | —          |
| <b>Chemistries</b>        |                  |            |
| ALP (U/L)                 | —                | —          |
| ALT (U/L)                 | —                | —          |

|                                |                                                                          |                                                                             |
|--------------------------------|--------------------------------------------------------------------------|-----------------------------------------------------------------------------|
| Anion gap                      | 6.9 (1.2-12.5)                                                           | —                                                                           |
| AST (U/L)                      | 49 (0-125)                                                               | 14.5 (3.6-61.2)                                                             |
| Bicarbonate (mmol/L)           | —                                                                        | —                                                                           |
| BUN (mg/dL)                    | —                                                                        | 1243 (1185-1293)                                                            |
| Calcium (mg/dL)                | 10.8 (9.5-12.5)                                                          | 16.5 (12.06-19.3)                                                           |
| Chloride (mEq/L)               | 139 (146-159)                                                            | 342 (301-362)                                                               |
| Cholesterol (mg/dL)            | —                                                                        | —                                                                           |
| Creatine kinase (U/L)          | —                                                                        | 80.5 (11.7-296.5)                                                           |
| Creatinine (mg/dL)             | 0.3 (0.2-0.4)                                                            | 0.3 (0.2-0.4)                                                               |
| Glucose (mg/dL)                | —                                                                        | 30.5 (16.9-42.4)                                                            |
| Lactate (mmol/L)               | —                                                                        | 3.1 (<2-6.2)                                                                |
| LDH (U/L)                      | 238 (65-692)                                                             | —                                                                           |
| Magnesium (mEq/L)              | —                                                                        | —                                                                           |
| Osmolality (mOsm/kg)           | —                                                                        | 1065 (1007-1144)                                                            |
| Phosphorus (mg/dL)             | 7.3 (4.1-8.9)                                                            | 4.7 (3-6.4)                                                                 |
| Potassium (mEq/L)              | 3.9 (2.7-5)                                                              | 5 (3.2-6.4)                                                                 |
| Protein, total (g/dL)          | —                                                                        | —                                                                           |
| Albumin (g/dL)                 | 0.9 (0.5-1)                                                              | —                                                                           |
| Globulin (g/dL)                | —                                                                        | —                                                                           |
| A:G (ratio)                    | —                                                                        | —                                                                           |
| Sodium (mEq/L)                 | 150 (146-159)                                                            | 315 (301-362)                                                               |
| Total CO <sub>2</sub> (mmol/L) | 7.5 (6-10)                                                               | —                                                                           |
| Uric acid (mg/dL)              | —                                                                        | —                                                                           |
| Measurement                    | Bonnethead shark ( <i>Sphyrna tiburo</i> ) <sup><a href="#">39</a></sup> | Sandbar shark ( <i>Carcharhinus plumbeus</i> ) <sup><a href="#">2</a></sup> |
| Hematology                     |                                                                          |                                                                             |
| PCV (%)                        | 24 (17-28)                                                               | 17.5-23                                                                     |
| RBC (10 <sup>6</sup> /μL)      | —                                                                        | —                                                                           |
| Hgb (g/dL)                     | —                                                                        | 7.6-10.1                                                                    |
| MCV (fL)                       | —                                                                        | —                                                                           |
| MCH (pg)                       | —                                                                        | —                                                                           |
|                                |                                                                          |                                                                             |

|                           |                  |                            |
|---------------------------|------------------|----------------------------|
| MCHC (g/dL)               | —                | —                          |
| WBC (10 <sup>3</sup> /μL) | —                | —                          |
| Heterophils (%)           | —                | 40-58 (total granulocytes) |
| Lymphocytes (%)           | —                | 40-55                      |
| Monocytes (%)             | —                | 2-6                        |
| Azurophils (%)            | —                | —                          |
| Eosinophils (%)           | —                | —                          |
| Basophils (%)             | —                | —                          |
| Chemistries               |                  |                            |
| ALP (U/L)                 | —                | —                          |
| ALT (U/L)                 | —                | —                          |
| Anion gap                 | -5.8 (-15.7-7.5) | —                          |
| AST (U/L)                 | 42 (15-132)      | —                          |
| Bicarbonate (mmol/L)      | 3 (0-5)          | —                          |
| BUN (mg/dL)               | 2812 (2644-2992) | —                          |
| Calcium (mg/dL)           | 16.8 (15.8-18.2) | —                          |
| Chloride (mEq/L)          | 290 (277-304)    | —                          |
| Cholesterol (mg/dL)       | —                | —                          |
| Creatine kinase (U/L)     | 82 (18-725)      | —                          |
| Creatinine (mg/dL)        | —                | —                          |
| Glucose (mg/dL)           | 184 (155-218)    | —                          |
| Lactate (mmol/L)          | —                | —                          |
| LDH (U/L)                 | <5 (<5-11)       | —                          |
| Magnesium (mEq/L)         | —                | —                          |
| Osmolality (mOsm/kg)      | 1094 (1056-1139) | —                          |
| Phosphorus (mg/dL)        | 8.8 (5.9-12.7)   | —                          |
| Potassium (mEq/L)         | 7.3 (5.7-9.2)    | —                          |
| Protein, total (g/dL)     | 2.9 (2.2-4.3)    | —                          |
| Albumin (g/dL)            | 0.4 (0.3-0.5)    | —                          |
| Globulin (g/dL)           | 2.6 (1.9-3.8)    | —                          |
| A:G (ratio)               | 0.1 (0.1-0.2)    | —                          |
| Sodium (mEq/L)            | 282 (273-292)    | —                          |
| Total CO <sub>2</sub>     | —                | —                          |

|                   |   |   |
|-------------------|---|---|
| (mmol/L)          |   |   |
| Uric acid (mg/dL) | — | — |

<sup>a</sup> Values listed are means except for the red pacu hematology and the shark data, which are medians. In some cases the data are not based on a large sample size. These values are only meant to be guidelines. Age of fish, time of year, and water temperature may all affect “normal” clinical pathological data.

## References

1. Ang CY, Liu FF, Lay JO, Jr., et al. Liquid chromatographic analysis of incurred amoxicillin residues in catfish muscle following oral administration of the drug. *J Agric Food Chem*. 2000;48:1673–1677.
2. Arnold J. Hematology of the sandbar shark (*Carcharhinus plumbeus*). *Vet Clin Path*. 2005;34:115–123.
3. Brenden RA, Huizinga HW. Pathophysiology of experimental *Aeromonas hydrophila* infection in goldfish, *Carassius auratus*. *J Fish Dis*. 1986;9:163–167.
4. Brown AG, Grant AN. Use of ampicillin by injection in Atlantic salmon broodstock. *Vet Rec*. 1992;131:237.
5. Buchmann K, Bjerregaard J. Mebendazole treatment of psuedodactylogyrosis in an intensive eel-culture system. *Aquaculture*. 1990;86:139–153.
6. Cain DK, Harms CA, Segars A. Plasma biochemistry reference values of wild-caught southern stingrays (*Dasyatis americana*). *J Zoo Wildl Med*. 2004;35:471–476.
7. Callahan HA, Noga EJ. Tricaine dramatically reduces the ability to diagnose protozoan ectoparasite (*Ichthyobodo necator*) infections. *J Fish Dis*. 2002;25:433–437.
8. Chen CY, Getchel RG, Wooster GA, et al. Oxytetracycline residues in four species of fish after 10-day oral dosing in feed. *J Aquat Anim Health*. 2004;16:208–219.

9. Colorni A, Paperna I. Evaluation of nitrofurazone baths in the treatment of bacterial infections of *Sparus aurata* and *Oreochromis massambicus*. *Aquaculture*. 1983;25:181–186.
10. Coyne R, Bergh O, Smith P, et al. A question of temperature related differences in plasma oxolinic acid concentrations achieved in rainbow trout (*Oncorhynchus mykiss*) under laboratory conditions following multiple oral dosing. *Aquaculture*. 2004;245:13–17.
11. Coyne R, Samuelsen O, Kongshaug H, et al. A comparison of oxolinic acid concentrations in farmed and laboratory held rainbow trout (*Oncorhynchus mykiss*) following oral therapy. *Aquaculture*. 2004;239:1–13.
12. Cravedi JP, Boudry G, Baradat M, et al. Metabolic fate of 2,4-dichloroaniline, prochloraz and nonylphenol diethoxylate in rainbow trout. a comparative in vivo/in vitro approach. *Aquat Toxicol*. 2001;53:159–172.
13. Cravedi JP, Heuillet G, Peleran JC, et al. Disposition and metabolism of chloramphenicol in trout. *Xenobiotica*. 1985;15:115–121.
14. Creeper JH, Buller NB. An outbreak of *Streptococcus iniae* in barramundi (*Lates calcarifera*) in freshwater cage culture. *Aust Vet J*. 2006;84:408–411.
15. Cross DG, Hursey PA. Chloramine-T for the control of *Ichthyophthirius multifiliis* (Fouquet). *J Fish Dis*. 1973;10:789–798.
16. Davis LE, Davis CA, Koritz GD, et al. Comparative studies of pharmacokinetics of fenbendazole in food-producing animals. *Vet Hum Toxicol*. 1988;30(Suppl 1):9–11.
17. della Rocca G, Di Salvo A, Malvisi J, et al. The disposition of enrofloxacin in seabream (*Sparus aurata* L.) after single intravenous injection or from medicated feed administration. *Aquaculture*. 2004;232:53–62.
18. della Rocca G, Zaghini A, Zanoni R, et al. Seabream (*Sparus aurata* L.). disposition of amoxicillin after single intravenous or oral administration and multiple dose depletion studies. *Aquaculture*. 2004;232:1–10.



19. Ding F, Cao J, Ma L, et al. Pharmacokinetics and tissue residues of difloxacin in crucian carp (*Carassius auratus*) after oral administration. *Aquaculture*. 2006;256:121–128.
20. Doi A, Stoskopf MK, Lewbart GA. Pharmacokinetics of oxytetracycline in the red pacu (*Colossoma brachypomum*) following different routes of administration. *J Vet Pharmacol Therap*. 1998;21:364–368.
21. Elston RA, Drum AS, Schweitzer MG, et al. Comparative update of orally administered difloxacin in Atlantic salmon in freshwater and seawater. *J Aquat Anim Health*. 1994;6:341–348.
22. Fairgrieve WT, Masada CL, McAuley WC, et al. Accumulation and clearance of orally administered erythromycin and its derivative, azithromycin, in juvenile fall Chinook salmon *Oncorhynchus tshawytscha*. *Dis Aquat Organ*. 2005;64:99–106.
23. Fairgrieve WT, Masada CL, Peterson ME, et al. Concentrations of erythromycin and azithromycin in mature Chinook salmon *Oncorhynchus tshawytscha* after intraperitoneal injection, and in their progeny. *Dis Aquat Organ*. 2006;68:227–234.
24. Fleming GJ, Corwin A, McCoy AJ, et al. Treatment factors influencing the use of recombinant platelet-derived growth factor (Regranex®) for head and lateral line erosion syndrome in ocean surgeonfish (*Acanthurus bahianus*). *J Zoo Wildl Med*. 2008;39:155–160.
25. Fleming GJ, Heard DJ, Francis-Floyd R, et al. Evaluation of propofol and medetomidine-ketamine for short-term immobilization of Gulf of Mexico sturgeon (*Acipenser oxyrinchus* De Soti). *J Zoo Wildl Med*. 2003;34:153–158.
26. Gilmartin WG, Camp BJ, Lewis DH. Bath treatment of channel catfish with three broad-spectrum antibiotics. *J Wildl Dis*. 1976;12:555–559.
27. Gingerich WH, Meinertsz JR, Dawson VK, et al. Distribution and elimination of [<sup>14</sup>C] sarafloxacin hydrochloride from tissues of juvenile channel catfish (*Ictalurus punctatus*). *Aquaculture*. 1995;131:23–36.

28. Gratzek JB, Shotts EB, Dawe DL. Infectious diseases and parasites of freshwater ornamental fish. Gratzek JB, Matthews FR. *Aquariology. The Science of Fish Health Management*. Morris Plains, NJ: Tetra Press; 1992:227–274.
29. Groff JM, Zinkl JG. Hematology and clinical chemistry of cyprinid fish. *Vet Clin North Am Exotic Anim Pract*. 1999;2:741–776.
30. Grondel JL, Nouws JFM, De Jong M, et al. Pharmacokinetics and tissue distribution of oxytetracycline in carp, *Cyprinus carpio* L., following different routes of administration. *J Fish Dis*. 1987;10:153–163.
31. Grosell MH, Hansen HJM, Rosenkilde P. Cu uptake, metabolism and elimination in fed and starved European eels (*Anguilla anguilla*) during adaptation to water-borne Cu exposure. *Comp Biochem Physiol C*. 1998;120:295–305.
32. Grosell MH, Hogstrand C, Wood CM. Cu uptake and turnover in both Cu-acclimated and non-acclimated rainbow trout (*Oncorhynchus mykiss*). *Aquat Toxicol*. 1997;38:257–276.
33. Grosell MH, Hogstrand C, Wood CM. Renal Cu and Na excretion and hepatic Cu metabolism in both Cu acclimated and non acclimated rainbow trout (*Oncorhynchus mykiss*). *Aquat Toxicol*. 1998;40:275–291.
34. Hansen MK, Horsberg TE. Single-dose pharmacokinetics of flumequine in cod (*Gadus morhua*) and goldsinny wrasse (*Ctenolabrus rupestris*). *J Vet Pharmacol Ther*. 2000;23:163–168.
35. Hansen MK, Nymoen U, Horsberg TE. Pharmacokinetic and pharmacodynamic properties of metomidate in turbot (*Scophthalmus maximus*) and halibut (*Hippoglossus hippoglossus*). *J Vet Pharmacol Ther*. 2003;26:95–103.
36. Harms CA. Treatments for parasitic diseases of aquarium and ornamental fish. *Semin Avian Exotic Pet Med*. 1996;5:54–63.
37. Harms CA. Anesthesia in fish. Fowler ME, Miller RE. *Zoo and Wild Animal Medicine. Current Therapy 4*. Philadelphia: WB Saunders Co; 1999:158–163.

38. Harms CA, Lewbart GA. Surgery in fish. *Vet Clin North Am Exotic Anim Pract.* 2000;3:759–774.
39. Harms CA, Ross T, Segars A. Plasma biochemistry reference values of wild bonnethead sharks, *Sphyrna tiburo*. *Vet Clin Pathol.* 2002;31:111–115.
40. Harms CA, Lewbart GA, Swanson CR, et al. Behavioral and clinical pathology changes in koi carp (*Cyprinus carpio*) subjected to anesthesia and surgery with and without intra-operative analgesics. *Comp Med.* 2005;55:221–226.
41. Harms CA, Sullivan CV, Hodson RG, et al. Clinical pathology and histopathology characteristics of net-stressed striped bass with “red tail.”. *J Aquat Anim Health.* 1996;8:82–86.
42. Heaton LH, Post G. Tissue residues and oral safety of furazolidone in four species of trout. *Prog Fish-Cult.* 1968;30:208–215.
43. Hubert TD, Bernardy JA, Vue C, et al. Residues of the lampricides 3-trifluoromethyl-4-nitrophenol and niclosamide in muscle tissue of rainbow trout. *J Agric Food Chem.* 2005;53:5342–5346.
44. Inglis V, Richards RH, Varma KJ, et al. Florfenicol in Atlantic salmon, *Salmo salar* L., parr. tolerance and assessment of efficacy against furunculosis. *J Fish Dis.* 1991;14:343–351.
45. Intorre L, Castells G, Cristofol C, et al. Residue depletion of thiamphenicol in the sea-bass. *J Vet Pharmacol Ther.* 2002;25:59–63.
46. Iosifidou EG, Haagsma N, Olling M, et al. Residue study of mebendazole and its metabolites hydroxymebendazole and amino-mebendazole in eel (*Anguilla anguilla*) after bath treatment. *Drug Metab Dispos.* 1997;25:317–320.
47. Iosifidou EG, Haagsma N, Tanck MWT, et al. Depletion study of fenbendazole in rainbow trout (*Oncorhynchus mykiss*) after oral and bath treatment. *Aquaculture.* 1997;154:191–199.
48. Jarboe H, Toth BR, Shoemaker KE, et al. Pharmacokinetics, bioavailability, plasma protein binding and disposition of nalidixic acid in rainbow trout

(*Oncorhynchus mykiss*). *Xenobiotica*. 1993;23:961–972.

49. Johnson EL. *Koi Health and Disease*. Athens: Reade Printers; 2006.

50. Jones J, Kinnel M, Christenson R, et al. Gentamicin concentrations in toadfish and goldfish serum. *J Aquat Anim Health*. 1997;9:211–215.

51. Kajita Y, Sakai M, Atsuta S, et al. The immunomodulatory effects of levamisole on rainbow trout, *Oncorhynchus mykiss*. *Fish Pathol*. 1990;25:93–98.

52. Kim MS, Lim JH, Park BK, et al. Pharmacokinetics of enrofloxacin in Korean catfish (*Silurus asotus*). *J Vet Pharmacol Ther*. 2006;29:397–402.

53. Kitzman JV, Holley JH, Huber WG, et al. Pharmacokinetics and metabolism of fenbendazole in channel catfish. *Vet Res Com*. 1990;14:217–226.

54. Kozlowski F. Chloromycetin levels in the blood and some tissues of carps in the prophylactic treatment of dropsy. *Bull Vet Instit Pulawy*. 1964;8:188–195.

55. Law FCP. Total metabolic depletion and residue profile of selected drugs in trout. furazolidone. Final FDA Report (Contract 223-90-7016); 1994.

56. Lewbart GA. Emergency pet fish medicine. Bonagura JD, ed. *Kirk's Current Veterinary Therapy XII. Small Animal Practice*. Philadelphia: WB Saunders Co; 1995:1369–1374.

57. Lewbart GA. Emergency and critical care of fish. *Vet Clin North Am Exotic Anim Pract*. 1998;1:233–249.

58. Lewbart GA. Koi medicine and management. *Suppl Comp Contin Educ Pract Vet*. 1998;20:5–12.

59. Lewbart GA. Fish supplement. In: Johnson-Delaney C, ed. *Exotic Companion Medicine Handbook*. West Palm Beach, FL: Zoological Medicine Network; 2006:1–58.

60. Lewbart GA, Papich MG, Whitt-Smith D. Pharmacokinetics of florfenicol in the red pacu (*Piaractus brachypomus*) after single dose intramuscular

administration. *J Vet Pharmacol Ther.* 2005;28:317–319.

61. Lewbart GA, Butkus DA, Papich M, et al. A simple catheterization method for systemic administration of drugs to fish. *J Am Vet Med Assoc.* 2005;226:784–788.

62. Lewbart GA, Vaden S, Deen J, et al. Pharmacokinetics of enrofloxacin in the red pacu (*Colossoma brachypomum*) after intramuscular, oral and bath administration. *J Vet Pharmacol Ther.* 1997;20:124–128.

63. Lewis DH, Wenxing W, Ayers A, et al. Preliminary studies on the use of chloroquine as a systemic chemotherapeutic agent for amyloodinosis in red drum (*Sciaenops ocellatus*). *Marine Sci Suppl.* 1988;30:183–189.

64. Meinertz JR, Stehly GR, Greseth SL, et al. Depletion of the chloramine-T marker residue, para-toluenesulfonamide, from skin-on fillet tissue of hybrid striped bass, rainbow trout, and yellow perch. *Aquaculture.* 2004;232:1–10.

65. Moffitt CM. Survival of juvenile Chinook salmon challenged with *Renibacterium salmoninarum* and administered oral doses of erythromycin thiocyanate for different durations. *J Aquat Anim Health.* 1992;4:119–125.

66. Nafstad I, Ingebrigsten K, Langseth W, et al. Benzimidazoles for antiparasite therapy in salmon. *Acta Vet Scand Suppl.* 1991;87:302–304.

67. Noga EJ. Fish Disease. Diagnosis and Treatment. 2nd ed. Ames: Wiley-Blackwell; 2010.

68. Noga EJ, Wang C, Grindem CB, et al. Comparative clinicopathological responses of striped bass and palmetto bass to acute stress. *Trans Am Fish Soc.* 1999;128:680–686.

69. Nouws JFM, Grondel JL, Schutte AR, et al. Pharmacokinetics of ciprofloxacin in carp, African catfish and rainbow trout. *Vet Quart.* 1988;10:211–216.

70. Palmeiro BS, Rosenthal KL, Lewbart GA, et al. Plasma biochemical reference intervals for koi. *J Am Vet Med Assoc.* 2007;230:708–712.

71. Plakas SM, DePaola A, Moxey MB. *Bacillus stearothermophilis* disk assay for

- determining ampicillin residues in fish muscle. *J Assoc Off Anal Chem Internat.* 1991;74:910–912.
72. Plakas SM, El Said KR, Stehly GR. Furazolidone disposition after intravascular and oral dosing in the channel catfish. *Xenobiotica.* 1994;24:1095–1105.
73. Plakas SM, El Said KR, Bencsath FA, et al. Pharmacokinetics, tissue distribution and metabolism of acriflavine and proflavine in the channel catfish (*Ictalurus punctatus*). *Xenobiotica.* 1998;28:605–616.
74. Plumb JA, Rogers WA. Effect of Droncit (praziquantel) on yellow grubs *Clinostomum marginatum* and eye flukes *Diplostomum spathaceum* in channel catfish. *J Aquat Anim Health.* 1990;2:204–206.
75. Pottinger TG, Day JG. A *Saprolegnia parasitica* challenge system for rainbow trout. assessment of Pyceze as an anti-fungal agent for both fish and ova. *Dis Aquatic Org.* 1999;36:129–141.
76. Rapp J. Treatment of rainbow trout (*Oncorhynchus mykiss* Walb.) fry infected with *Ichthyophthirius multifiliis* by oral administration of dimetridazole. *Bull Euro Assoc Fish Pathol.* 1995;15:67–69.
77. Reimschuessel R, Chamie SJ, Kinnel M. Evaluation of gentamicin-induced nephrotoxicosis in toadfish. *J Am Vet Med Assoc.* 1996;209:137–139.
78. Reimschuessel R, Stewart L, Squibb E, et al. Fish Drug Analysis—Phish-Pharm. A Searchable Database of Pharmacokinetics Data in Fish. *AAPS J.* 2005;07(02):E288–E327. 10.1208/aapsj070230. <http://www.aapsj.org/view.asp?art=aapsj070230>, Feb 1, 2011. Accessed
79. Reja A, Moreno L, Serrano JM, et al. Concentration-time profiles of oxytetracycline in blood, kidney and liver of tench (*Tinca tinca* L.) after intramuscular administration. *Vet Hum Toxicol.* 1996;38:344–347.
80. Roberts HE, Palmeiro B, Weber ES, III. Bacterial and parasitic diseases of pet fish. *Vet Clin North Am Exotic Anim Pract.* 2009;12:609–638.

81. Robertson B, Rorstad G, Engstad R, et al. Enhancement of non-specific disease resistance in Atlantic salmon, *Salmo salar* L., by a glucan from *Saccharomyces cerevisiae* cell walls. *J Fish Dis*. 1990;13:391–400.
82. Rogstad A, Ellingsen OF, Syvertsen C. Pharmacokinetics and bioavailability of flumequine and oxolinic acid after various routes of administration to Atlantic salmon in seawater. *Aquaculture*. 1993;110:207–220.
83. Sakamoto K, Lewbart GA, Smith TM, II. Blood chemistry values of juvenile red pacu (*Piaractus brachypomus*). *Vet Clin Path*. 2001;30:50–52.
84. Samuelsen OB. Pharmacokinetics of quinolones in fish. A review. *Aquaculture*. 2006;255:55–75.
85. Samuelsen OB, Bergh O. Efficacy of orally administered florfenicol and oxolinic acid for the treatment of vibriosis in cod (*Gadus morhua*). *Aquaculture*. 2004;235:27–35.
86. Samuelsen OB, Ervik A. Single dose pharmacokinetic study of flumequine after intravenous, intraperitoneal and oral administration to Atlantic halibut (*Hippoglossus hippoglossus*) held in seawater at 9°C. *Aquaculture*. 1997;158:215–227.
87. Samuelsen OB, Ervik A. Absorption, tissue distribution, and excretion of flumequine and oxolinic acid in corkscrew wrasse (*Symphodus melops*) following a single intraperitoneal injection or bath treatment. *J Vet Pharmacol Ther*. 2001;24:111–116.
88. Samuelsen OB, Bergh O, Ervik A. Pharmacokinetics of florfenicol in cod (*Gadus morhua*) and in vitro antibacterial activity against *Vibrio anguillarum*. *Dis Aquat Organ*. 2003;56:127–133.
89. Schering Plough. Schering Plough Animal Health Technical Report 2001. <http://www.spaquaculture.com/default.aspx?pageid=545>, Jan 19, 2011. Accessed
90. Schmahl G, Benini J. Treatment of fish parasites 11. Effects of different benzimidazole derivatives (albendazole, mebendazole, fenbendazole) on *Glugea anomala*, Moniez, 1887 (Microsporidia). Ultrastructural aspects and efficacy

studies. *Parasitol Res.* 1998;60:41–49.

91. Setser MD. Pharmacokinetics of gentamicin in channel catfish (*Ictalurus punctatus*). *Am J Vet Res.* 1985;46:2558–2561.

92. Shaikh B, Rummel N, Gieseke C, et al. Metabolism and residue depletion of albendazole in rainbow trout, tilapia, and Atlantic salmon after oral administration. *J Vet Pharmacol Ther.* 2003;26:421–428.

93. Siwicki AK, Anderson DP, Rumsey GL. Dietary intake of immunostimulants by rainbow trout affects non-specific immunity and protection against furunculosis. *Vet Immunol Immunopathol.* 1994;41:125–139.

94. Stoffregen DA, Chako AJ, Backman S, et al. Successful therapy of furunculosis in Atlantic salmon *Salmo salar* L. using the fluoroquinolone antimicrobial agent enrofloxacin. *J Fish Dis.* 1993;16:219–227.

95. Stoskopf MK. Appendix V. chemotherapeutics. Stoskopf MK, ed. *Fish Medicine*. Philadelphia: WB Saunders Co; 1993:832–839.

96. Stoskopf MK. Anesthesia of pet fishes. Bonagura JD, ed. *Kirk's Current Veterinary Therapy XII. Small Animal Practice*. Philadelphia: WB Saunders Co; 1995:1365–1369.

97. Stoskopf MK. Fish pharmacotherapeutics. Fowler ME, Miller RE. *Zoo and Wild Animal Medicine. Current Therapy 4*. Philadelphia: WB Saunders Co; 1999:182–189.

98. Stoskopf MK, Kennedy-Stoskopf S, Arnold J, et al. Therapeutic aminoglycoside antibiotic levels in brown shark, *Carcharhinus plumbeus* (Nardo). *J Fish Dis.* 1986;9:303–311.

99. Tarascheewski H, Renner C, Melhorn H. Treatment of fish parasites 3. Effects of levamisole HCl, metrifonate, fenbendazole, mebendazole, and ivermectin in *Anguillicola crassus* (nematodes) pathogenic in the air bladder of eels. *Parasitol Res.* 1988;74:281–289.

100. Tociłowski ME, Lewbart GA, Stoskopf MK. Hematologic study of red pacu



(*Colosomma brachypomum*). *Vet Clin Path*. 1997;26:119–125.

101. Thomasen JM. Hydrogen peroxide as a delousing agent for Atlantic salmon. Boxshall GA, Defaye D. *Pathogens of Wild and Farmed Fish. Sea Lice*. Chichester, England: Ellis Horwood; 1993:290–295.
102. Treves-Brown KM. *Applied Fish Pharmacology*. Dordrecht, The Netherlands: Kluwer Academic Publishers; 2000.
103. Tripathi NK, Latimer KS, Brunley VV. Hematologic reference intervals for koi (*Cyprinus carpio*), including blood cell morphology, cytochemistry, and ultrasturcture. *Vet Clin Pathol*. 2004;33:74–83.
104. Whitaker BR. Preventive medicine programs for fish. Fowler ME, Miller RE. *Zoo and Wild Animal Medicine. Current Therapy 4*. Philadelphia: WB Saunders Co; 1999:163–181.
105. Wildgoose WH, Lewbart GA. Therapeutics. In: Wildgoose WH, ed. *Manual of Ornamental Fish*. 2nd ed. Gloucester, England: British Small Animal Veterinary Association; 2001:237–258.
106. Willoughby LG, Roberts RJ. Towards strategic use of fungicides against *Saprolegnia parasitica* in salmonid fish hatcheries. *J Fish Dis*. 1992;15:1–13.
107. Woynarovich E, Horvath L. *The Artificial Propagation of Warm-Water Finfishes—A Manual for Extension Fisheries*. Rome: Technical Paper 201, FAO; 1980.
108. Xu D, Rogers WA. Formaldehyde residue in striped bass muscle. *J Aquat Anim Health*. 1993;5:306–312.
109. Xu W, Zhu X, Wang X, et al. Residues of enrofloxacin, furazolidone and their metabolites in Nile tilapia (*Oreochromis niloticus*). *Aquaculture*. 2006;254:1–8.
110. Yanong RPE. Personal communication; 2011.
111. Yanong RPE, Curtis EW. Pharmacokinetic studies of florfenicol in koi carp

and threespot gourami *Trichogaster trichopterus* after oral and intramuscular treatment. *J Aquat Anim Health*. 2005;17:129–137.

112. Zimmerman DM, Armstrong DL, Curro TG, et al. Pharmacokinetics of florfenicol after a single intramuscular dose in white-spotted bamboo sharks (*Chiloscyllium plagiosum*). *J Zoo Wildl Med*. 2006;37:165–173.

# Chapter 3

## Amphibians

Kevin Wright, Ryan S. DeVoe

TABLE 3-1 Antimicrobial Agents Used in Amphibians. [a](#), [b](#)

| Agent                             | Dosage                                                            | Species/Comments                                                                                                                                                                                                                                              |
|-----------------------------------|-------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Amikacin                          | 5 mg/kg SC, IM, ICe q24-48h <sup><a href="#">54</a></sup>         | Most species; may be used in combination with piperacillin                                                                                                                                                                                                    |
|                                   | 5 mg/kg IM q36h <sup><a href="#">21</a></sup>                     | Bullfrogs/PD                                                                                                                                                                                                                                                  |
| Carbenicillin                     | 100 mg/kg SC, IM q72h <sup><a href="#">6</a></sup>                |                                                                                                                                                                                                                                                               |
|                                   | 200 mg/kg SC, IM, ICe q24h <sup><a href="#">31</a></sup>          |                                                                                                                                                                                                                                                               |
| Ceftazidime                       | 20 mg/kg SC, IM q48-72h <sup><a href="#">53</a></sup>             |                                                                                                                                                                                                                                                               |
| Chloramphenicol                   | 50 mg/kg SC, IM, ICe q12-24h <sup>31</sup>                        | Caution: even miniscule exposures carries risk of aplastic anemia in susceptible individuals; wear disposable gloves when handling; aplastic anemia-like findings in <i>Bufo regularis</i> exposed to 125 mg/kg PO q24h × 12 wk <sup><a href="#">11</a></sup> |
|                                   | 20 mg/L bath changed daily <sup><a href="#">31</a></sup>          |                                                                                                                                                                                                                                                               |
| Ciprofloxacin                     | 10 mg/kg PO q24h <sup><a href="#">54</a></sup>                    |                                                                                                                                                                                                                                                               |
|                                   | 500-750 mg/75 L as 6-8 hr bath q24h <sup><a href="#">54</a></sup> | May be used for large numbers of animals                                                                                                                                                                                                                      |
| Doxycycline (Psittavet, Vetafarm) | 50 mg/kg IM q7d <sup><a href="#">53</a></sup>                     | Broad-spectrum antibiotic, part of 4-quadrant therapy; may have antiinflammatory effect; chlamydophilosis                                                                                                                                                     |
| Doxycycline (Vibramycin, Pfizer)  | 5-10 mg/kg PO q24h <sup><a href="#">50</a></sup>                  | Chlamydophilosis                                                                                                                                                                                                                                              |
|                                   | 10-50 mg/kg PO q24h <sup><a href="#">35</a></sup>                 | African clawed frogs/chlamydophilosis                                                                                                                                                                                                                         |
|                                   | Apply topically                                                   |                                                                                                                                                                                                                                                               |

|                                                                     |                                                                  |                                                                                                                    |
|---------------------------------------------------------------------|------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------|
| Doxycycline 1% topical gel, compounded                              | q8-12h not to exceed 10 mg/kg per day <sup>53</sup>              | Useful for localized lesions; may have antiinflammatory effect                                                     |
| Enrofloxacin (Baytril, Bayer)                                       | 5-10 mg/kg PO, SC, IM q24h <sup>21,54</sup>                      | Most species/PD (bullfrogs); <sup>21</sup> ICe and topical routes also used but without PD <sup>54</sup>           |
|                                                                     | 500 mg/L as 6-8 hr bath q24h <sup>53</sup>                       |                                                                                                                    |
| Enrofloxacin and silver sulfadiazine solution (Baytril Otic, Bayer) | Apply topically to lesions q12h <sup>53</sup>                    | May have some antifungal effect, but does not appear effective on chytrid                                          |
| Gentamicin                                                          | 2-4 mg/kg IM q72h × 4 treatments <sup>15</sup>                   |                                                                                                                    |
|                                                                     | 2.5 mg/kg IM q72h <sup>38</sup>                                  | Coldwater salamanders (i.e., <i>Necturus</i> )/PD; more frequent dosing may be needed if temperature >4°C (39.2°F) |
|                                                                     | 3 mg/kg IM q24h at 22.2°C (72°F) <sup>39</sup>                   | Leopard frogs/PD; at higher temperatures, serum concentrations will be lower                                       |
|                                                                     | Topical to eyes <sup>48</sup>                                    | All species/ocular infections; dilute to 2 mg/mL                                                                   |
|                                                                     | Intracameral injection once, not to exceed 4 mg/kg <sup>53</sup> | Panophthalmitis                                                                                                    |
|                                                                     | 1.3 mg/L × 1 hr bath q24h × 7 days <sup>15</sup>                 | Bacterial dermatitis; can be toxic                                                                                 |
| Isoniazid                                                           | 12.5 mg/L bath <sup>35</sup>                                     | Mycobacteriosis; therapy may be enhanced with additional medications <sup>53</sup>                                 |
| Metronidazole                                                       | 10 mg/kg PO q24h × 5-10 days <sup>30</sup>                       | For chronic diarrhea                                                                                               |
|                                                                     | 10 mg/kg IV q24h × 2 days <sup>54</sup>                          | Anaerobic infections                                                                                               |
|                                                                     | 12 mg/kg topically q24h × 5-10 days <sup>54</sup>                | For chronic diarrhea                                                                                               |
|                                                                     | 20 mg/kg PO                                                      |                                                                                                                    |

|                                                                 |                                                      |                                                                                                                                   |
|-----------------------------------------------------------------|------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------|
|                                                                 | q48h × 20 days <sup>53</sup>                         | Anaerobic infections                                                                                                              |
|                                                                 | 50 mg/kg PO<br>q24h × 3 days <sup>54</sup>           | Anaerobic infections                                                                                                              |
|                                                                 | 60 mg/kg<br>topically q24h<br>× 3 days <sup>54</sup> | Anaerobic infections                                                                                                              |
|                                                                 | 50 mg/L × 24<br>hr bath <sup>54</sup>                | Anaerobic infections                                                                                                              |
| Neomycin, polymixin B,<br>bacitracin<br><br>(Neosporin, Pfizer) | Apply topically<br>to wound<br>q24h <sup>13</sup>    | Microsporidian infections; not recommended for<br>bacterial infections, appears to inhibit re-<br>epithelialization <sup>53</sup> |
| Nifurpirinol (Furanace,<br>Dainippon)                           | 250 mg/38 L ×<br>1 hr bath<br>q24h <sup>15</sup>     |                                                                                                                                   |
| Nitrofurazone                                                   | 10-20 mg/L ×<br>24 hr bath <sup>6</sup>              | Change daily                                                                                                                      |
| Oxytetracycline                                                 | 25 mg/kg SC,<br>IM q24h <sup>31</sup>                | Most species                                                                                                                      |
|                                                                 | 50 mg/kg PO<br>q12-24h <sup>31</sup>                 | Most species                                                                                                                      |
|                                                                 | 50-100 mg/kg<br>IM q48h <sup>21</sup>                | Bullfrogs/PD; especially useful in cases of<br>chlamydophilosis (use up to 30 days) <sup>54</sup>                                 |
|                                                                 | 100 mg/L × 1<br>hr bath <sup>54</sup>                | Most species                                                                                                                      |
|                                                                 | 1 g/kg feed × 7<br>days <sup>31</sup>                | Most useful with axolotls and <i>Xenopus</i> fed<br>compounded pelleted diet <sup>53</sup>                                        |
| Piperacillin                                                    | 100 mg/kg SC,<br>IM q24h <sup>54</sup>               | Anaerobes; may be used in combination with<br>amikacin                                                                            |
| Rifampin                                                        | 25 mg/L × 24<br>hr bath <sup>12</sup>                | Potentially effective for mycobacteriosis; therapy<br>may be enhanced with additional medications <sup>53</sup>                   |
| Silver sulfadiazine (Silvadine<br>Cream 1%, Marion)             | Topical q24h <sup>12</sup>                           | Antibiotic cream                                                                                                                  |
| Sulfadiazine                                                    | 132 mg/kg PO<br>q24h <sup>31</sup>                   |                                                                                                                                   |
| Sulfamethazine                                                  | 1 g/L bath to<br>effect <sup>31</sup>                | Change daily                                                                                                                      |
|                                                                 |                                                      |                                                                                                                                   |

|                               |                                                                                             |                                               |
|-------------------------------|---------------------------------------------------------------------------------------------|-----------------------------------------------|
| Tetracycline                  | 50 mg/kg PO<br>q12h <sup>6</sup>                                                            |                                               |
|                               | 150 mg/kg PO<br>q24h × 5-7<br>days <sup>46</sup>                                            |                                               |
|                               | 167 mg/kg (5<br>mg/30 g) PO<br>q12h × 7 days <sup>15</sup>                                  |                                               |
| Trimethoprim/sulfa            | 3 mg/kg PO,<br>SC, IM q24h <sup>6</sup>                                                     | Unspecified sulfa                             |
| Trimethoprim/sulfadiazine     | 15-20 mg/kg<br>IM q48h <sup>23</sup>                                                        | Chronic diarrhea <sup>53</sup>                |
| Trimethoprim/sulfamethoxazole | 15 mg/kg PO<br>q24h <sup>54</sup>                                                           | Chronic diarrhea                              |
|                               | 20 µg/mL and<br>80 µg/mL in<br>0.5% or 0.15%<br>salt solution ×<br>24 hr bath <sup>24</sup> | Bacterial dermatosepticemia; make fresh daily |

<sup>a</sup> Water baths containing antibiotics or topical applications may not provide as consistent distribution as parenteral administration.

<sup>b</sup> SC can be administered in the dorsal lymph sac of anurans.<sup>7</sup>

TABLE 3-2 Antifungal Agents Used in Amphibians.

| Agent                 | Dosage                                                                           | Species/Comments                   |
|-----------------------|----------------------------------------------------------------------------------|------------------------------------|
| Amphotericin B        | 1 mg/kg ICe<br>q24h <sup>54</sup>                                                | Internal mycoses                   |
| Benzalkonium chloride | 0.25 mg/L × 72<br>hr bath <sup>6</sup>                                           |                                    |
|                       | 2 mg/L × 1 hr<br>bath q24h <sup>31</sup>                                         | Saprolegniasis                     |
|                       | 1:4,000,000<br>bath <sup>31</sup>                                                | Saprolegniasis; change water 3×/wk |
| Chloramphenicol       | 20 mg/kg<br>topically (applied<br>as Chlorsig<br>ointment which<br>also contains |                                    |

|                 |                                                                                |                                                                                                                                                                                                                                                                                                                                                                          |
|-----------------|--------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                 | paraffin and wool fat) <sup>2</sup>                                            |                                                                                                                                                                                                                                                                                                                                                                          |
|                 | 10 mg/L (10 ppm) as continuous bath replaced fresh daily <sup>2</sup>          | Chytridiomycosis; safe for larvae, recent metamorphs, and adults; confirm negative result by real-time PCR; <sup>2,53</sup> caution: even miniscule exposure carries risk of aplastic anemia in susceptible individuals; wear disposable gloves when handling; aplastic anemia-like findings in <i>Bufo regularis</i> exposed to 125 mg/kg PO q24h × 12 wk <sup>11</sup> |
|                 | 20 ppm as continuous bath replaced fresh daily for up to 30 days <sup>29</sup> |                                                                                                                                                                                                                                                                                                                                                                          |
|                 | 30 ppm as continuous bath replaced fresh daily for up to 30 days <sup>53</sup> |                                                                                                                                                                                                                                                                                                                                                                          |
| Florfenicol     | 30 ppm as continuous bath replaced fresh daily for up to 30 days <sup>53</sup> |                                                                                                                                                                                                                                                                                                                                                                          |
| Fluconazole     | 60 mg/kg PO q24h <sup>54</sup>                                                 |                                                                                                                                                                                                                                                                                                                                                                          |
| Itraconazole    | 10 mg/kg PO q24h <sup>54</sup>                                                 | Topical route best choice to treat chytridiomycosis; do not use with larvae <sup>27</sup>                                                                                                                                                                                                                                                                                |
|                 | 0.01% in 0.6% salt solution as 5 min bath q24h × 11 days <sup>27</sup>         |                                                                                                                                                                                                                                                                                                                                                                          |
| Ketoconazole    | 10 mg/kg PO q24h <sup>31</sup>                                                 |                                                                                                                                                                                                                                                                                                                                                                          |
|                 | 10-20 mg/kg PO q24h <sup>54</sup>                                              |                                                                                                                                                                                                                                                                                                                                                                          |
|                 | Topical cream <sup>8</sup>                                                     | Topical route best choice to treat chytridiomycosis; do not use with larvae <sup>53</sup>                                                                                                                                                                                                                                                                                |
| Malachite green | 0.15-0.2 mg/L × 1 hr bath q24h <sup>15</sup>                                   | Cutaneous mycoses; caution: mutagenic, teratogenic; potentially toxic                                                                                                                                                                                                                                                                                                    |
| Mercurochrome   | 4 mg/L × 1 hr bath q24h <sup>47</sup>                                          | Saprolegniasis                                                                                                                                                                                                                                                                                                                                                           |
| Methylene blue  | 2-4 mg/L bath to effect <sup>6</sup>                                           | Tadpoles/reduces mortality in newly hatched tadpoles                                                                                                                                                                                                                                                                                                                     |

|                                         |                                             |                                                                                                                           |
|-----------------------------------------|---------------------------------------------|---------------------------------------------------------------------------------------------------------------------------|
|                                         | 4 mg/L × 1 hr bath q24h <sup>47</sup>       | Saprolegniasis                                                                                                            |
| Miconazole                              | 5 mg/kg ICe q24h × 14-28 days <sup>52</sup> | Systemic mycoses                                                                                                          |
|                                         | Topical cream or solution <sup>54</sup>     | Topical route best choice for chytridiomycosis; solutions containing alcohol may cause irritation; do not use with larvae |
| Nystatin 1% cream                       | Topical <sup>53</sup>                       | Cutaneous mycoses                                                                                                         |
| Potassium permanganate                  | 1:5000 water × 5 min bath q24h <sup>4</sup> | Cutaneous mycoses                                                                                                         |
| Sodium chlorite (NaOCl <sub>2</sub> )   | 20 mg/L as 6-8 hr bath <sup>51</sup>        | Cutaneous mycoses                                                                                                         |
| Temperature elevation                   | 37°C (98.6°F) for 16 hr <sup>49</sup>       | Chytridiomycosis; lower temperatures (down to 30°C [86°F]) may be effective with longer duration <sup>53</sup>            |
| Tolnaftate (Tinavet cream 1%, Schering) | Topical <sup>15</sup>                       | Cutaneous mycoses                                                                                                         |

TABLE 3-3 Antiparasitic Agents Used in Amphibians.<sup>a</sup>

| Agent                                                                                  | Dosage                                                          | Species/Comments                                      |
|----------------------------------------------------------------------------------------|-----------------------------------------------------------------|-------------------------------------------------------|
| Acriflavin                                                                             | 0.025% bath × 5 days <sup>31</sup>                              | Protozoa                                              |
|                                                                                        | 500 mg/L × 30 min bath <sup>45</sup>                            | Protozoa                                              |
| Benzalkonium chloride                                                                  | 2 mg/L × 1 hr bath q24h to effect <sup>45</sup>                 | Protozoa                                              |
| Copper sulfate                                                                         | 0.1 mg/L as a continuous bath to effect <sup>54</sup>           | Some protozoa; copper may be toxic to some amphibians |
|                                                                                        | 500 mg/L × 2 min bath q24h to effect <sup>31</sup>              |                                                       |
| Distilled water                                                                        | 3 hr bath <sup>31</sup>                                         | Protozoa                                              |
| Febantel (in combination with pyrantel palmoate and praziquantel; Drontal Plus, Bayer) | 0.01 mL/1 g (10 mL/kg) PO q2-3wk <sup>28</sup>                  | Nematodes, cestodes, possibly trematodes              |
| Fenbendazole                                                                           | —                                                               | Fenbendazole combinations follow                      |
|                                                                                        | 30-50 mg/kg PO <sup>7</sup>                                     | Gastrointestinal nematodes                            |
|                                                                                        | 50 mg/kg PO q24h × 3-5 days, repeat in 14-21 days <sup>54</sup> | Resistant nematode infections                         |
|                                                                                        |                                                                 |                                                       |



|                                    |                                                                                                     |                                                                                                                                                  |
|------------------------------------|-----------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------|
|                                    | 50-100 mg/kg PO, <a href="#">30</a> repeat in 2-3 wk prn                                            | Most species/gastrointestinal nematodes                                                                                                          |
|                                    | 100 mg/kg PO, <a href="#">42</a> repeat in 14 days                                                  | Gastrointestinal nematodes                                                                                                                       |
| Fenbendazole (F)/ivermectin (I)    | (F) 100 mg/kg PO on day 1, then (I) 0.2 mg/kg PO on days 2,11 <a href="#">42</a>                    | Gastrointestinal nematodes                                                                                                                       |
| Fenbendazole (F)/metronidazole (M) | (F) 100 mg/kg PO, repeat in 10-14 days + (M) 10 mg/kg PO q24h for 5 days <a href="#">42</a>         | Concurrent gastrointestinal nematodes and protozoa                                                                                               |
| Formalin (10%)                     | —                                                                                                   | Do not use if skin is ulcerated                                                                                                                  |
|                                    | 1.5 mL/L × 10 min bath q48h to effect <a href="#">8</a>                                             | Protozoans; may be toxic in some species                                                                                                         |
|                                    | 0.5% × 10 min bath once <a href="#">31</a>                                                          | Monogenic trematodes; may be toxic to some amphibian species                                                                                     |
| Ivermectin                         | —                                                                                                   | Caution: may cause flaccid paralysis with overdosage; caffeine or physostigmine may ameliorate effects <a href="#">53</a>                        |
|                                    | 0.2-0.4 mg/kg PO, SC, repeat q14d prn <a href="#">7</a>                                             | Nematodes, including lungworms; mites                                                                                                            |
|                                    | 2 mg/kg topically, repeat in 2-3 wk <a href="#">20</a>                                              | Especially useful for small specimens <a href="#">54</a> and <i>Rana</i> spp <a href="#">20</a>                                                  |
|                                    | 10 mg/L as 60 min bath, repeat q14d prn <a href="#">54</a>                                          | Best route for treating mites                                                                                                                    |
| Levamisole                         | —                                                                                                   | May cause paralysis in some species at suggested dosages; <a href="#">54</a> caffeine or physostigmine may ameliorate effects <a href="#">53</a> |
|                                    | 10 mg/kg IM, <a href="#">6</a> ICe, <a href="#">52</a> topically, <a href="#">54</a> repeat in 2 wk | Nematodes, including lungworms                                                                                                                   |
|                                    | 12 mg/L bath × 4 days <a href="#">14</a>                                                            | African clawed frogs/cutaneous nematodes; use ≥4.2 L of tank water/frog                                                                          |
|                                    | 100 mg/L × ≥72 hr bath <a href="#">54</a>                                                           | Resistant nematodes                                                                                                                              |
|                                    | 100-300 mg/L × 24 hr bath, repeat in 1-2 wk <a href="#">54</a>                                      | Nematodes, including subcutaneous nematodes in aquatic amphibians; water soluble form is available through aquaculture supply companies          |
| Malachite green                    | —                                                                                                   | Caution: mutagenic, teratogenic; potentially toxic                                                                                               |
|                                    | 0.15 mg/L × 1 hr bath q24h to                                                                       |                                                                                                                                                  |

|                                    |                                                                                                                                                     |                                                                                                                        |
|------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------|
|                                    | effect <sup>31</sup>                                                                                                                                | Protozoa                                                                                                               |
| Metronidazole                      | —                                                                                                                                                   | See fenbendazole for combination                                                                                       |
|                                    | 10 mg/kg PO q24h × 5-10 days <sup>42</sup>                                                                                                          | Protozoa; for unfamiliar or sensitive species                                                                          |
|                                    | 50 mg/kg PO q24h × 3-5 days <sup>54</sup>                                                                                                           | Confirmed cases of amoebiasis and flagellate overload                                                                  |
|                                    | 100 mg/kg PO q3d <sup>8</sup>                                                                                                                       | Protozoa                                                                                                               |
|                                    | 100-150 mg/kg PO, repeat in 2-3 wk or prn <sup>31</sup>                                                                                             | Protozoa (i.e., <i>Entamoeba</i> , <i>Hexamita</i> , <i>Opalina</i> )                                                  |
|                                    | 0.05 mL of 1.008 mg/mL on dorsum q24h × 3 days <sup>26</sup>                                                                                        | Fire-bellied toads (1.8 g)/protozoa; rinse 1 hr after treatment; results in absorption of 23 mg/kg BW of metronidazole |
|                                    | 50 mg/L × 24 hr bath <sup>35</sup>                                                                                                                  | Aquatic amphibians/protozoa                                                                                            |
|                                    | 500 mg/100 g feed × 3-4 treatments <sup>6</sup>                                                                                                     | Ciliates                                                                                                               |
| Moxidectin                         | 200 µg/kg SC q4mo <sup>34</sup>                                                                                                                     | Nematodes                                                                                                              |
| Oxfendazole                        | 5 mg/kg PO <sup>46</sup>                                                                                                                            | Gastrointestinal nematodes                                                                                             |
| Oxytetracycline                    | 25 mg/kg SC, IM q24h <sup>45</sup>                                                                                                                  | Protozoa                                                                                                               |
|                                    | 50 mg/kg PO q12h <sup>45</sup>                                                                                                                      | Protozoa                                                                                                               |
|                                    | 1 g/kg feed × 7 days <sup>45</sup>                                                                                                                  | Protozoa                                                                                                               |
| Paromomycin (Humatin, Parke Davis) | 50-75 mg/kg PO q24h <sup>52</sup>                                                                                                                   | Gastrointestinal protozoa                                                                                              |
| Piperazine                         | 50 mg/kg PO, repeat in 2 wk <sup>15</sup>                                                                                                           | Gastrointestinal nematodes                                                                                             |
| Ponazuril                          | 30 mg/kg PO q12h × 3 days, repeat in 3 wk; often more effective at 30 mg/kg PO q24h × 30 days; may work with less frequent treatments <sup>53</sup> | Coccidia but not <i>Cryptosporidium</i> ; may have some effect on unidentified protozoan cysts                         |
| Potassium permanganate             | 7 mg/L × 5 min bath q24h to effect <sup>31</sup>                                                                                                    | Ectoparasitic protozoa                                                                                                 |
| Praziquantel                       | 8-24 mg/kg PO, SC, ICe, topically, repeat q14d <sup>54</sup>                                                                                        | Trematodes, cestodes                                                                                                   |
|                                    | 10 mg/L × 3 hr bath, repeat q7-21d <sup>54</sup>                                                                                                    | Trematodes, cestodes                                                                                                   |
| Pyrantel pamoate                   | 5 mg/kg PO q14d <sup>28</sup>                                                                                                                       | Nematodes                                                                                                              |
| Ronidazole                         | 10 mg/kg PO q24h × 10 days <sup>53</sup>                                                                                                            | Flagellated protozoa, amoebas                                                                                          |
| Salt (sodium chloride)             | 4-6 g/L bath <sup>31</sup>                                                                                                                          | Ectoparasitic protozoa                                                                                                 |
|                                    | 6 g/L × 5-10 min bath q24h × 3-5 days <sup>45</sup>                                                                                                 | Ectoparasitic protozoa                                                                                                 |
|                                    | 25 g/L × ≤10 min bath <sup>8</sup>                                                                                                                  | Ectoparasitic protozoa                                                                                                 |

|                                    |                                                      |                                     |
|------------------------------------|------------------------------------------------------|-------------------------------------|
| Selamectin<br>(Revolution, Pfizer) | 6 mg/kg topically <sup>9</sup>                       | Bullfrogs/PD                        |
| Sulfadiazine                       | 132 mg/kg PO q24h <sup>45</sup>                      | Coccidiosis                         |
| Sulfamethazine                     | 1 g/L bath <sup>45</sup>                             | Coccidiosis; change daily to effect |
| Tetracycline                       | 50 mg/kg PO q12h <sup>45</sup>                       | Protozoa                            |
| Thiabendazole                      | 50-100 mg/kg PO, <sup>15</sup> repeat in 2 wk<br>prn | Gastrointestinal nematodes          |
|                                    | 100 mg/L bath, repeat in 2 wk <sup>47</sup>          | Verminous dermatitis                |
| Trimethoprim/sulfa                 | 3 mg/kg PO, SC, IM q24h <sup>45</sup>                | Coccidiosis; unspecified sulfa      |

<sup>a</sup> SC can be administered in the dorsal lymph sac of anurans.<sup>7</sup>

TABLE 3-4 Chemical Restraint/Anesthetic/Analgesic Agents Used in Amphibians.<sup>a</sup>

| Agent                                         | Dosage                                   | Species/Comments <sup>b</sup>                                                                                                                                                                                                                               |
|-----------------------------------------------|------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Alfaxan (Vetafarm)                            | 5-10 mg/kg IM <sup>53</sup>              | May supplement with IM or IV                                                                                                                                                                                                                                |
| Atipamezole<br>(Antisedan, Pfizer)            | Titrate to effect                        | Antagonist for dexmedetomidine <sup>22</sup>                                                                                                                                                                                                                |
| Benzocaine (Sigma Chemical)                   | —                                        | Anesthesia; not sold as fish anesthetic in US; available from chemical supply companies; do not use topical anesthetic products marketed for mammals; prepare stock solution in ethanol (poorly soluble in water); store in dark bottle at room temperature |
|                                               | 50 mg/L bath to effect <sup>7</sup>      | Larvae/dissolve in ethanol first                                                                                                                                                                                                                            |
|                                               | 200-300 mg/L bath to effect <sup>7</sup> | Frogs, salamanders/dissolve in ethanol first                                                                                                                                                                                                                |
|                                               | 200-500 mg/L bath <sup>5</sup>           | Dissolve in acetone first                                                                                                                                                                                                                                   |
| Buprenorphine<br>(Buprenex, Reckitt & Colman) | 38 mg/kg SC <sup>22</sup>                | Analgesia >4 hr; ED <sub>50</sub> in leopard frogs <sup>22</sup>                                                                                                                                                                                            |
| Butorphanol                                   | 0.2-0.4 mg/kg IM <sup>33</sup>           | Analgesia; efficacy uncertain <sup>53</sup>                                                                                                                                                                                                                 |
| Clove oil (eugenol)                           | 0.3 mL/L (~310-318 mg/L) <sup>18</sup>   | Anesthesia; deep anesthesia after 15 min bath; caused reversible gastric prolapse in 50% of leopard frogs                                                                                                                                                   |
|                                               |                                          |                                                                                                                                                                                                                                                             |

|                                    |                                                                                           |                                                                                                                                                                                                     |
|------------------------------------|-------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                                    | 0.45 mL/L (~473 mg/L) <sup>25</sup>                                                       | Anesthesia; deep anesthesia induced in 80% of tiger salamanders                                                                                                                                     |
| Codeine                            | 53 mg/kg SC <sup>22</sup>                                                                 | Analgesia >4 hr; ED <sub>50</sub> in leopard frogs                                                                                                                                                  |
| Dexmedetomidine (Precedex, Abbott) | 40-120 mg/kg SC <sup>22</sup>                                                             | Analgesia >4 hr; ED <sub>50</sub> in leopard frogs                                                                                                                                                  |
| Diazepam                           | —                                                                                         | See ketamine for combination                                                                                                                                                                        |
| Fentanyl                           | 0.5 mg/kg SC <sup>22</sup>                                                                | Analgesia >4 hr; ED <sub>50</sub> in leopard frogs                                                                                                                                                  |
| Isoflurane                         | —                                                                                         | Anesthesia; induction chamber; inhalant of choice                                                                                                                                                   |
|                                    | 3-5% induction, 1-2% maintenance <sup>33</sup>                                            | Terrestrial species                                                                                                                                                                                 |
|                                    | 5% <sup>3</sup>                                                                           | Terrestrial species/euthanasia; induction chamber                                                                                                                                                   |
|                                    | Topical application of liquid isoflurane <sup>36</sup>                                    | <i>Bufo</i> spp (0.015 mL/g BW), African clawed frogs (0.007 mL/g BW)/induce in closed container; once induced, remove excess from animal                                                           |
|                                    | Topical mixture of isoflurane (3 mL), KY jelly (3.5 mL), and water (1.5 mL) <sup>36</sup> | <i>Bufo</i> spp (0.035 mL/g BW), African clawed frogs (0.025 mL/g BW)/induce in closed container; once induced, remove excess from animal                                                           |
|                                    | 0.28 mL/100 mL bath <sup>36</sup>                                                         | Induce in closed container                                                                                                                                                                          |
|                                    | Bubbled into water to effect <sup>36</sup>                                                | Aquatic species                                                                                                                                                                                     |
| Ketamine                           | —                                                                                         | May have long induction and recovery times; does not provide good analgesia so may not be suited for major surgical procedures; other agents preferred; ketamine combination follows; see lidocaine |
|                                    | 50-150 mg/kg SC, IM <sup>7</sup>                                                          | Most species                                                                                                                                                                                        |
| Ketamine (K)/diazepam (D)          | (K) 20-40 mg/kg + (D) 0.2-0.4 mg/kg IM <sup>33</sup>                                      | Variable results                                                                                                                                                                                    |

|                                           |                                                         |                                                                                                                                                                                                                                                                                        |
|-------------------------------------------|---------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Lidocaine 1-2%                            | Local infiltration <sup>16</sup>                        | All/local anesthesia; with or without epinephrine; 2% lidocaine in combination with ketamine has been used for minor surgeries; <sup>33</sup> use with caution                                                                                                                         |
| Meloxicam (Metacam; Boehringer Ingelheim) | 0.4 mg/kg PO, SC, ICe q24h <sup>53</sup>                | Analgesia                                                                                                                                                                                                                                                                              |
| Methoxyflurane                            | 0.5-1 mL in 1 L container (cotton soaked) <sup>16</sup> | Induction in 2 min; surgical anesthesia maintained for about 30 min; recovery within 7 hr; not recommended because of potential of overdose <sup>33</sup>                                                                                                                              |
| Morphine                                  | 38-42 mg/kg SC <sup>22</sup>                            | Analgesia >4 hr                                                                                                                                                                                                                                                                        |
| Nalorphine                                | 122 mg/kg SC <sup>22</sup>                              | Analgesia >4 hr                                                                                                                                                                                                                                                                        |
| Naloxone                                  | 10 mg/kg SC; <sup>22</sup> titrate to effect            | Antagonist for buprenorphine, butorphanol, codeine, fentanyl, morphine                                                                                                                                                                                                                 |
| Naltrexone                                | 1 mg/kg SC; <sup>22</sup> titrate to effect             | Antagonist for buprenorphine, butorphanol, codeine, fentanyl, morphine                                                                                                                                                                                                                 |
| Pentobarbital sodium                      | 40-50 mg/kg ICe <sup>33</sup>                           | Frogs, toads/seldom used; other agents preferred; can also administer in dorsal lymph sac; anesthesia and recovery are prolonged                                                                                                                                                       |
|                                           | 60 mg/kg IV, ICe <sup>3</sup>                           | Euthanasia; ICe is preferred route; can also be administered in lymph sacs in anurans                                                                                                                                                                                                  |
| Propofol                                  | 10-30 mg/kg ICe <sup>41</sup>                           | White's tree frogs/pilot study; use the lower dosage for sedation or light anesthesia; induction within 30 min; recovery in 24 hr                                                                                                                                                      |
|                                           | 35 mg/kg ICe <sup>25</sup>                              | Deep anesthesia in 83% of tiger salamanders <sup>25</sup>                                                                                                                                                                                                                              |
|                                           | 60-100 mg/kg ICe <sup>41</sup>                          | Euthanasia                                                                                                                                                                                                                                                                             |
|                                           | 100-140 mg/kg topically <sup>53</sup>                   | Unpublished data; maroon-eyed tree frogs ( <i>Agalychnis litodryas</i> ); 15-20 min to max effect at 100 mg/kg dose, 10-15 min to max effect at 140 mg/kg; <sup>53</sup> sedation to deep anesthesia; remove and rinse when desired level achieved; recommended only for animals <50 g |
| Sevoflurane                               | Topical application                                     | Rapid recovery unless constant reapplication                                                                                                                                                                                                                                           |
|                                           | Topical mixture of                                      |                                                                                                                                                                                                                                                                                        |

|                                                      |                                                               |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
|------------------------------------------------------|---------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                                                      | sevoflurane (5 mL) + water soluble jelly (5 mL) <sup>53</sup> |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
| Tiletamine/zolazepam (Telazol, Fort Dodge)           | 10-20 mg/kg IM <sup>33</sup>                                  | Results variable between species; rapid recovery; not suitable as single anesthetic agent for anurans <sup>19</sup>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
| Tricaine methanesulfonate (MS-222) (Finquel, Argent) | —                                                             | Anesthesia; buffer the acidity by adding sodium bicarbonate to buffer the solution to a pH of 7.0-7.1; <sup>10</sup> aerate water to prevent hypoxemia; remove from bath on induction or overdosing can readily occur; following bath, place terrestrial amphibians on moist towel or in very shallow water to recover; <sup>6</sup> some species can be induced at much lower concentrations than listed here; <sup>52</sup> in some cases, anesthesia can be maintained by dripping a dilute solution of this drug (100-200 mg/L) over the skin or by covering animal with a paper towel moistened with the anesthetic <sup>52</sup> |
|                                                      | 50-200 mg/kg SC, IM, ICe <sup>10</sup>                        | Most species/may be irritating administered SC, IM (neutral solution is preferred) <sup>10</sup>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
|                                                      | 100-200 mg/kg ICe <sup>37</sup>                               | Leopard frogs                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
|                                                      | 100-400 mg/kg ICe <sup>37</sup>                               | Bullfrogs                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
|                                                      | 100-200 mg/L bath to effect <sup>44</sup>                     | Larvae/induction                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
|                                                      | 200-500 mg/L bath to effect <sup>7</sup>                      | Tadpoles, newts/induction in 15-30 min                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
|                                                      | 0.5-2 g/L bath to effect <sup>7</sup>                         | Frogs, salamanders/induction in 15-30 min                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
|                                                      | 1 g/L bath to effect <sup>10</sup>                            | Most gill-less adult species (unless very large)/induction                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
|                                                      | 2-3 g/L bath to effect <sup>54</sup>                          | Toads/induction in 15-30 min                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
|                                                      | 10 g/L bath <sup>3</sup>                                      | Euthanasia; can be administered ICe or in lymph sacs                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |

<sup>a</sup> SC can be administered in dorsal lymph sac in anurans.<sup>7</sup>

<sup>b</sup> ED<sub>50</sub>, effective dose for 50% of the population.

TABLE 3-5 Hormones Used in Amphibians.<sup>a</sup>

| Agent                                   | Dosage                                                                                     | Species/Comments                                                                                             |
|-----------------------------------------|--------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------|
| Gonadotropin-releasing hormone (GnRH)   | 10 µg SC to female followed by additional 20 µg after 18 hr; 5 µg SC to male <sup>43</sup> | Tomato frogs ( <i>Dyscophus guineti</i> )/ovulation and spermiation                                          |
|                                         | 0.1 mg/kg SC, IM, repeat prn <sup>31</sup>                                                 | Induction of ovulation in those non-responsive to PMSG or hCG; administer to females 8-12 hr before males    |
| Human chorionic gonadotropin (hCG)      | 50-100 <sup>7</sup> to 300 <sup>31</sup> U SC, IM                                          | For mating or release of sperm in males; follow with GnRH in 8-24 hr                                         |
|                                         | 250-400 U SC, IM <sup>7</sup>                                                              | African clawed frogs, axolotls/induction of ovulation; may be used with PMSG and/or progesterone             |
| Luteinizing hormone–releasing hormone   | 10 µg in 0.05 mL of 40% DMSO applied to ventral drink patch <sup>32</sup>                  | <i>Bufo americanus</i> and <i>B. valliceps</i> /induced spermiation in 70% of males                          |
|                                         | 5 µg ICe per animal <sup>40</sup>                                                          | Salamanders ( <i>Desmognathus ochrophaeus</i> )/induced oviposition in 94%                                   |
| Pregnant mare serum gonadotropin (PMSG) | 50-200 U SC, IM <sup>7</sup>                                                               | African clawed frogs, axolotls/induction of ovulation; administer 600 U hCG SC, IM 72 hr later <sup>31</sup> |
| Progesterone                            | 1-5 mg SC, IM <sup>7</sup>                                                                 | African clawed frogs, axolotls/use in addition to PMSG or hCG for induction of ovulation                     |

<sup>a</sup> SC can be administered into the dorsal lymph sac of anurans.<sup>7</sup>

TABLE 3-6 Miscellaneous Agents Used in Amphibians.<sup>a</sup>

| Agent                             | Dosage                                                                                                       | Species/Comments                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
|-----------------------------------|--------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Amphibian Ringer’s solution (ARS) | 6.6 g NaCl, 0.15 g KCl, 0.15 g CaCl <sub>2</sub> , and 0.2 g NaHCO <sub>3</sub> in 1 L water <sup>8,54</sup> | For treating hydrocoelom and subcutaneous edema; place animal in shallow ARS bath until stabilized (≈24 hr or more); replace with fresh solution daily; may need to wean animal off ARS by placing it in gradually more dilute solutions; <sup>54</sup> hypertonic solution created by using 800-950 mL water instead of 1 L and may be more effective for some cases of hydrocoelom; <sup>54</sup> up to 10 g of glucose may be added per L, but then solution must be made fresh daily <sup>53</sup> |
| Atropine                          | 0.1 mg SC, IM prn <sup>54</sup>                                                                              | Organophosphate toxicosis                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
|                                   | Use caffeinated tea bag; steep                                                                               | Stimulant; may help reverse ivermectin or                                                                                                                                                                                                                                                                                                                                                                                                                                                              |



|                                                |                                                                                                 |                                                                                                                                                                                                                                                                                        |
|------------------------------------------------|-------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Caffeine                                       | (soak) until solution is “weak tea”; place amphibian in shallow bath, replace q6h <sup>53</sup> | levamisole toxicosis, or excessively deep anesthesia <sup>53</sup>                                                                                                                                                                                                                     |
| Calcium glubionate                             | 1 mL/kg PO q24h <sup>54</sup>                                                                   | Nutritional secondary hyperparathyroidism                                                                                                                                                                                                                                              |
| Calcium gluconate                              | 100-200 mg/kg SC <sup>54</sup>                                                                  | Hypocalcemic tetany                                                                                                                                                                                                                                                                    |
|                                                | 2.3% continuous bath (with 2-3 IU/mL vitamin D <sub>3</sub> ) <sup>54</sup>                     | Nutritional secondary hyperparathyroidism                                                                                                                                                                                                                                              |
| Critical care diets                            |                                                                                                 |                                                                                                                                                                                                                                                                                        |
| • Carnivore Critical Care (Oxbow)              | 3% bodyweight PO q24-72h <sup>53</sup>                                                          | Dosage is approximate; may be more appropriate to offer larger volume less frequently for easily stressed animals                                                                                                                                                                      |
| • Emeraid for Carnivores (Lafeber)             | 3% BW PO q24-48h <sup>53</sup>                                                                  | Dosage is approximate; may be more appropriate to offer larger volume less frequently for easily stressed animals                                                                                                                                                                      |
| • Feline Clinical Care Liquid (Pet-Ag)         | 1-2 mL/50 g PO q24h <sup>53</sup>                                                               | Dosage is approximate; may be more appropriate to offer larger volume less frequently for easily stressed animals                                                                                                                                                                      |
|                                                | 3-6 mL/50 g PO q72h <sup>53</sup>                                                               |                                                                                                                                                                                                                                                                                        |
| • Hill’s Feline a/d (Hill’s Pet Nutrition)     | PO <sup>8</sup>                                                                                 | Nutritional support; mix 1:1 with water; generally gavaged                                                                                                                                                                                                                             |
| Cyanoacrylate surgical adhesive (Vet Bond, 3M) | Topical on wounds <sup>8</sup>                                                                  | Produces a seal for aquatic and semiaquatic species                                                                                                                                                                                                                                    |
| Dexamethasone                                  | 1.5 mg/kg SC, IM <sup>48</sup>                                                                  | Vascularizing keratitis                                                                                                                                                                                                                                                                |
|                                                | 1.5 mg/kg IM, IV <sup>53</sup>                                                                  | Shock                                                                                                                                                                                                                                                                                  |
| Dextrose 5% solution                           | Bath                                                                                            | For treating hydrocoelom and subcutaneous edema; <sup>54</sup> place animal in shallow bath until stabilized (<24 hr or more); replace with fresh solution daily; may need to wean animal off dextrose by placing it in gradually more dilute solutions; 7.5-10% solutions may be more |



|                                                  |                                                                                                                                                                                                                                                                                                               |                                                                                                                                                                                                                                                                                                                                                    |
|--------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                                                  |                                                                                                                                                                                                                                                                                                               | effective for some cases of hydrocoelom                                                                                                                                                                                                                                                                                                            |
| Doxycycline                                      | 1.25-2.5 mg/kg PO, SC, ICe q24h <sup>53</sup>                                                                                                                                                                                                                                                                 | Antiinflammatory                                                                                                                                                                                                                                                                                                                                   |
|                                                  | 1% gel topically q12h <sup>53</sup>                                                                                                                                                                                                                                                                           | Antiinflammatory                                                                                                                                                                                                                                                                                                                                   |
| Hetastarch (6% in 0.9% saline)                   | Bath not to exceed 1 hr without reassessment <sup>53</sup>                                                                                                                                                                                                                                                    | May help with initial treatment of some hydrocoelom                                                                                                                                                                                                                                                                                                |
| Laxative (Laxatone, Evsco)                       | PO <sup>8</sup>                                                                                                                                                                                                                                                                                               | Laxative, especially for intestinal foreign bodies                                                                                                                                                                                                                                                                                                 |
| Meloxicam                                        | 0.4 mg/kg PO, SC, ICe q24h <sup>53</sup>                                                                                                                                                                                                                                                                      | Antiinflammatory; presumptive analgesia; adjunct therapy for septicemia                                                                                                                                                                                                                                                                            |
|                                                  | 0.5% gel topically q24h; do not exceed 0.4 mg/kg <sup>53</sup>                                                                                                                                                                                                                                                | Antiinflammatory for localized wounds                                                                                                                                                                                                                                                                                                              |
| Methylene blue                                   | 2 mg/mL bath to effect <sup>54</sup>                                                                                                                                                                                                                                                                          | Nitrite and nitrate toxicoses                                                                                                                                                                                                                                                                                                                      |
| Oxygen                                           | 100% for up to 24 hr <sup>54</sup>                                                                                                                                                                                                                                                                            | Adjunct treatment for septicemia, toxicoses                                                                                                                                                                                                                                                                                                        |
| Physostigmine (ophthalmic drops)                 | 1 drop/50 g topically q1-2h to effect <sup>53</sup>                                                                                                                                                                                                                                                           | May ameliorate flaccid paralysis from ivermectin or levamisole toxicosis                                                                                                                                                                                                                                                                           |
| Prednisolone sodium succinate                    | 5-10 mg/kg IM, IV <sup>54</sup>                                                                                                                                                                                                                                                                               | Shock                                                                                                                                                                                                                                                                                                                                              |
| Sodium thiosulfate                               | 1% solution as continuous bath to effect <sup>54</sup>                                                                                                                                                                                                                                                        | Halogen toxicoses                                                                                                                                                                                                                                                                                                                                  |
| Vitamin A (Aquasol A, 50,000 U/mL, Mayne Pharma) | Dilute 1:9 with sterile water; make fresh weekly; apply 1 drop from a tuberculin syringe with 27-g needle to amphibians under 5 g; 1 drop from tuberculin syringe w/out needle is about 200 U and useful for 15-30 g BW; over that try 1 drop per 10 g BW; topically q24h × 14 days, then q4-7d <sup>17</sup> | Hypovitaminosis A; given the plethora of organ systems that hypovitaminosis A may affect, it is reasonable to institute vitamin A supplementation of any clinically ill amphibian, particularly ones with signs similar to “short tongue syndrome,” swollen eyelids, evidence of infectious dermatitis, hydrocoelom, or simply “failing to thrive” |
|                                                  | 1 U/g PO daily × 14 days <sup>53</sup>                                                                                                                                                                                                                                                                        |                                                                                                                                                                                                                                                                                                                                                    |
| Vitamin A gel caps (10,000 U/cap)                | Dilute 1:9 with corn oil to yield 1000 U/mL, give 1 U/g PO q24h × 14 days, then q7d <sup>53</sup>                                                                                                                                                                                                             | Hypovitaminosis A; given the plethora of organ systems that hypovitaminosis A may affect, it is reasonable to institute vitamin A supplementation of any clinically ill amphibian, particularly ones with signs similar to “short tongue syndrome,” swollen eyelids, evidence of infectious dermatitis, hydrocoelom, or simply “failing to thrive” |
|                                                  |                                                                                                                                                                                                                                                                                                               | Deficiency resulting from thiaminase-containing                                                                                                                                                                                                                                                                                                    |

|                              |                                                                      |                                           |
|------------------------------|----------------------------------------------------------------------|-------------------------------------------|
| Vitamin B <sub>1</sub>       | 25 mg/kg feed fish <sup>23</sup>                                     | fish                                      |
| Vitamin D <sub>3</sub>       | 2-3 U/mL continuous bath (with 2.3% calcium gluconate) <sup>54</sup> | Nutritional secondary hyperparathyroidism |
|                              | 100-400 U/kg PO q24h <sup>54</sup>                                   |                                           |
| Vitamin E (alpha-tocopherol) | 1 mg/kg PO, IM q7d <sup>54</sup>                                     |                                           |
|                              | 200 U/kg feed <sup>31</sup>                                          | Steatitis                                 |

<sup>a</sup> SC can be administered into the dorsal lymph sac of anurans.<sup>7</sup>

TABLE 3-7 Physiologic and Hematologic Values of Amphibians.<sup>a,1,7</sup>

| Measurement                | African clawed frog ( <i>Xenopus laevis</i> ) | American bullfrog ( <i>Rana catesbeiana</i> ) | Cuban tree frog ( <i>Hyla septentrionalis</i> ) | Edible frog ( <i>Rana esculenta</i> ) | Grass frog ( <i>Rana temporaria</i> ) | Leopard frog ( <i>Rana pipiens</i> ) |           | Mud-puppy ( <i>Necturus maculatus</i> ) | Tiger salamander ( <i>Ambystoma tigrinum</i> ) |
|----------------------------|-----------------------------------------------|-----------------------------------------------|-------------------------------------------------|---------------------------------------|---------------------------------------|--------------------------------------|-----------|-----------------------------------------|------------------------------------------------|
|                            |                                               |                                               |                                                 |                                       |                                       | ♂ <sup>a</sup>                       | ♀         |                                         |                                                |
| BW (g)                     | —                                             | 225-306                                       | 28-35                                           | —                                     | —                                     | 25-42                                | 25-46     | —                                       | 35                                             |
| Blood volume (mL/100 g BW) | —                                             | 3.1-3.6                                       | 7.2-7.8                                         | —                                     | —                                     | —                                    | —         | —                                       | —                                              |
| Hematology                 |                                               |                                               |                                                 |                                       |                                       |                                      |           |                                         |                                                |
| PCV (%)                    | —                                             | 39-42                                         | 20-24                                           | —                                     | —                                     | 19-52                                | 16-51     | 21                                      | 40                                             |
| RBC (10 <sup>3</sup> /μL)  | 566                                           | 450                                           | —                                               | 308                                   | 461                                   | 227-767                              | 174-701   | 20                                      | 1657                                           |
| Hgb (g/dL)                 | 14.9                                          | 9.3-9.7                                       | 5.6-6.8                                         | 9.7                                   | 14.34                                 | 3.8-14.6                             | 2.7-14    | 4.6                                     | 9.4                                            |
| MCV (fL)                   | —                                             | —                                             | —                                               | —                                     | —                                     | 722-916                              | 730-916   | 10,070                                  | —                                              |
| MCH (pg)                   | —                                             | —                                             | —                                               | —                                     | —                                     | 182-221                              | 182-238   | 2160                                    | —                                              |
| MCHC (g/dL)                | —                                             | 21.1-25.9                                     | 25-31                                           | —                                     | —                                     | 22.7-26.8                            | 19.9-27.7 | 22                                      | —                                              |
| WBC (10 <sup>3</sup> /μL)  | 8.2                                           | —                                             | —                                               | 6.1                                   | 14.4                                  | 3.1-22.2                             | 2.8-25.9  | —                                       | 4.6                                            |
| Early stages (%)           | 0.7                                           | —                                             | —                                               | 1                                     | 1.5                                   | —                                    | —         | —                                       | —                                              |
| Neutrophils (%)            | 8 ± 1.1                                       | —                                             | —                                               | 8.8 ± 2.1                             | 6.5 ± 1                               | —                                    | —         | —                                       | —                                              |
| Lymphocytes (%)            | 65.3 ± 2.7                                    | —                                             | —                                               | 52 ± 3.3                              | 68.5 ± 2.9                            | —                                    | —         | —                                       | —                                              |
| Monocytes (%)              | 0.5                                           | —                                             | —                                               | 1.3                                   | 0.8                                   | —                                    | —         | —                                       | —                                              |

Continued

| Measurement                        | African clawed frog ( <i>Xenopus laevis</i> ) | American bullfrog ( <i>Rana catesbeiana</i> ) | Cuban tree frog ( <i>Hyla septentrionalis</i> ) | Edible frog ( <i>Rana esculenta</i> ) | Grass frog ( <i>Rana temporaria</i> ) | Leopard frog ( <i>Rana pipiens</i> ) |   | Mud-puppy ( <i>Necturus maculatus</i> ) | Tiger salamander ( <i>Ambystoma tigrinum</i> ) |
|------------------------------------|-----------------------------------------------|-----------------------------------------------|-------------------------------------------------|---------------------------------------|---------------------------------------|--------------------------------------|---|-----------------------------------------|------------------------------------------------|
|                                    |                                               |                                               |                                                 |                                       |                                       | ♂ <sup>a</sup>                       | ♀ |                                         |                                                |
| Eosinophils (%)                    | —                                             | —                                             | —                                               | 19.4 ± 1.3                            | 14.5 ± 2.9                            | —                                    | — | —                                       | —                                              |
| Basophils (%)                      | 8.5 ± 1.4                                     | —                                             | —                                               | 16.6 ± 1.3                            | 24.2 ± 2.2                            | —                                    | — | —                                       | —                                              |
| Plasmocytes (%)                    | 0.2                                           | —                                             | —                                               | 1                                     | 0.4                                   | —                                    | — | —                                       | —                                              |
| Thrombocytes (10 <sup>3</sup> /μL) | 17.1                                          | —                                             | —                                               | 16.3                                  | 20.8                                  | —                                    | — | —                                       | —                                              |

<sup>a</sup>Hematology is presently of limited diagnostic value because of the lack of normal data and the wide variation in hematologic and biochemical values according to sex, season, and state of hydration.

TABLE 3-8 Differential Diagnoses by Predominant Signs in Amphibians.<sup>a</sup>

| Sign                    | Common causes                                                                                                                                                                                                                                                | Suggested diagnostics <sup>b</sup>                                                                                                                                                                                                                                                                                                                                             |
|-------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Changes in skin color   | Infectious agents: virus, bacteria, mycobacteria nodules, saprolegniasis, chromoblastomycosis, other mycoses, protozoa, myxosporeans, microsporidia, helminths ( <i>Capillaroidea xenopi</i> ), leeches, fly larvae, other arthropods, fish lice, mollusks   | Biology review of species in question; husbandry review (diet, water quality tests, soil pH, temperature); skin scrapes (wet mount and stained); PCR tests for ranavirus and chytrid; skin and blood cultures; fecal parasite exams; plasma cholesterol and triglycerides; radiograph for skeletal density; plasma calcium and phosphorus; CBC and other plasma biochemistries |
|                         | Noninfectious causes: toxicosis, hypothermia, hyperthermia, dehydration, dessication, burn, frostbite, trauma, neoplasia, nutritional secondary hyperparathyroidism, xanthomatosis/hyperlipidosis, drug reaction                                             |                                                                                                                                                                                                                                                                                                                                                                                |
| Changes in skin texture | Infectious agents: virus, bacteria, mycobacteria, mycoses, protozoa, myxosporeans, microsporidia, helminths, fly larvae, leeches, mites, ticks, fish lice, other arthropods, mollusks                                                                        | Biology review of species in question; husbandry review (diet, water quality tests, soil pH, temperature); skin scrapes (wet mount and stained); PCR tests for ranavirus and chytrid; skin and blood cultures; fecal parasite exams; CBC and plasma biochemistries                                                                                                             |
|                         | Noninfectious causes: toxicosis, hypothermia, hyperthermia, dehydration, dessication, stress, trauma (especially rostral abrasion), neoplasia, normal (e.g., dorsal crests in European newts, egg brood patch of Surinam toad, nuptial pads in male anurans) |                                                                                                                                                                                                                                                                                                                                                                                |
| Excess mucus production | Infectious agents: virus, bacteria, mycoses, protozoa, helminths, arthropods, mollusks                                                                                                                                                                       | Husbandry review (diet, water quality tests, soil pH, temperature); skin scrapes (wet mount and stained); PCR tests for ranavirus and chytrid; skin and blood culture; fecal parasite exams; CBC and plasma biochemistries                                                                                                                                                     |
|                         | Noninfectious causes: toxicosis (ammonia, nitrite, chlorine, chloramine, salt, nicotine), poor water quality (pH, hardness, supersaturation), stress (cagemate, escape behavior, inappropriate soil pH or composition), hyperthermia, trauma                 |                                                                                                                                                                                                                                                                                                                                                                                |
| Fluctuant mass          | Infectious agents: bacterial abscess, mycobacteria (rare), mycoses (rare), protozoal cyst, myxosporeans, helminths (e.g., immature trematodes and cestodes), subcutaneous leeches, fly larvae, mites, pentastomes                                            | Biology review of species in question; husbandry review (diet, water quality tests, soil pH, temperature); aspirate (wet mount, stained, culture); fecal parasite exams; plasma uric acid, cholesterol, and triglycerides; radiograph for skeletal density; plasma                                                                                                             |
|                         | Noninfectious causes: lymphatic blockage (e.g., gout), xanthomatosis, toxicosis, trauma, fluid overload, thermal injury, hypocalcemia, neoplasia, normal (e.g., active marsupium of <i>Gastrotheca</i> spp females, water                                    |                                                                                                                                                                                                                                                                                                                                                                                |

|                       |                                                                                                                                                                                                                                                                                |                                                                                                                                                                                                                                                                                                                                                                    |
|-----------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                       | sacs of <i>Cycloderma rana</i> , distended lymphatic sacs of <i>Ceratophrys</i> spp)                                                                                                                                                                                           | calcium and phosphorus; skin and blood cultures; CBC and other plasma chemistries                                                                                                                                                                                                                                                                                  |
| Corneal opacity       | Infectious agents: bacteria, mycoses, nematodes                                                                                                                                                                                                                                | Husbandry review; slit lamp ophthalmic exam; culture and sensitivity; plasma cholesterol and triglycerides                                                                                                                                                                                                                                                         |
|                       | Noninfectious causes: scar, corneal lipidosis/xanthomatosis, trauma, chemical irritation, toxicosis, neoplasia                                                                                                                                                                 |                                                                                                                                                                                                                                                                                                                                                                    |
| Sudden death          | Infectious agents: iridovirus, bacteria, chamydophilosis, chytridiomycosis                                                                                                                                                                                                     | Biology review of species in question; husbandry review (diet, water quality tests, soil pH, temperature); PCR tests for ranavirus and chytrid; necropsy of dead specimens; physical exam of cagemates (include CBC, plasma biochemistries, blood culture, fecal parasite exams); consider euthanasia and necropsy of one or more cagemates                        |
|                       | Noninfectious causes: toxicosis (ammonia, household pesticides, chlorine), electrocution, hypothermia, hyperthermia, trauma, gastric overload/impaction, stress, drowning, neoplasia                                                                                           |                                                                                                                                                                                                                                                                                                                                                                    |
| Weight loss           | Infectious agents: chromomycosis, mycobacteria, coccidiosis, flagellate or ciliate overgrowth, helminths                                                                                                                                                                       | Biology review of species in question; husbandry review (diet, water quality tests, soil pH, temperature); skin scrapes (wet mount and stained); fecal parasite exams; PCR tests for ranavirus and chytrid; CBC; skin and blood cultures; plasma calcium, phosphorus, cholesterol, and triglycerides; radiograph for skeletal density; other plasma biochemistries |
|                       | Noninfectious causes: heavy metal toxicosis (e.g., copper), chemical irritation (e.g., ammonia, chlorine, salt, pH), stress from inappropriate husbandry (e.g., environmental temperature too high, cagemate aggression), ocular disease with vision impairment, xanthomatosis |                                                                                                                                                                                                                                                                                                                                                                    |
| Anorexia, inappetence | Infectious agents: iridovirus, Lucke's herpesvirus, other virus, bacteria, mycobacteria, chytridiomycosis, chromoblastomycosis, mucormycosis, protozoa, myxosporean, microsporidial, helminth, fly larvae, pentastomes, mites, ticks                                           | Biology review of species in question; husbandry review (diet, water quality tests, soil pH, temperature); skin scrapes (wet mount and stained); PCR tests for ranavirus and chytrid; skin and blood cultures; fecal                                                                                                                                               |
|                       | Noninfectious causes: inappropriate environment (e.g., substrate, temperature, illumination, photoperiod, humidity, lack of furnishings and hiding spots, inappropriate cagemates, too many cagemates or visible specimens in adjacent cages, activity in room),               |                                                                                                                                                                                                                                                                                                                                                                    |

|             |                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                                                                                                                                                                                                                                                                                                                                 |
|-------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|             | inappropriate feeding practices (e.g., wrong kind of food/prey, wrong size of food/prey, feeding at wrong times, too many prey items offered at one time), frequent handling or cage servicing, nutritional secondary hyperparathyroidism, hypocalcemia, toxicosis (e.g., copper, ammonia, chlorine), xanthomatosis, ocular disease with vision impairment, neoplasia, geriatric/senescence, normal (i.e., estivation or hibernation cues) | parasite exams; plasma cholesterol and triglycerides; radiograph for skeletal density; plasma calcium and phosphorus; CBC and other plasma biochemistries                                                                                                                                                                                       |
| Bloating    | Infectious agents: virus, bacteria, mycoses, mycobacteria, gastrointestinal nematodes                                                                                                                                                                                                                                                                                                                                                      | Biology review of species in question; husbandry review (diet, water quality tests, soil pH, temperature); fecal parasite exams; PCR tests for ranavirus and chytrid; plasma calcium and phosphorus; radiograph; aspirate (wet mount, stained, culture); plasma biochemical analysis; ultrasonography; radiograph; skin and blood cultures; CBC |
|             | Noninfectious causes: hypocalcemia (especially in hylid frogs), toxicosis, hypothermia, decomposition of ingesta (e.g., gastric overload, low or high temperatures), pneumocoelom (i.e., ruptured lung or trachea), gas supersaturation                                                                                                                                                                                                    |                                                                                                                                                                                                                                                                                                                                                 |
| Hydrocoelom | Infectious agents: virus, bacteria, mycoses, mycobacteria, verminous granulomata, filarids, other helminths                                                                                                                                                                                                                                                                                                                                | Biology review of species in question; husbandry review (diet, water quality tests, soil pH, temperature); aspirate (wet mount, stained, culture); fecal parasite exams; PCR tests for ranavirus and chytrid; plasma biochemical analysis; ultrasonography; radiograph; skin and blood cultures; CBC                                            |
|             | Noninfectious causes: toxicosis (e.g., heavy metal, chlorine, ammonia, insecticide, distilled or reverse osmosis water), hepatic failure, renal failure, hypocalcemia, xanthomatosis, gout, neoplasia (especially ovarian, hepatic, or renal), failure to oviposit, normal (e.g., ovulation)                                                                                                                                               |                                                                                                                                                                                                                                                                                                                                                 |
| Lameness    | Infectious agents: virus, bacteria, mycobacteria, mycoses, protozoa, myxosporeans, microsporidia, helminths, fly larvae, pentastomes, mites                                                                                                                                                                                                                                                                                                | Husbandry review (diet, water quality tests, soil pH, temperature); radiograph; plasma calcium and phosphorus; plasma cholesterol and triglycerides; fecal parasite exams; CBC and other plasma chemistries                                                                                                                                     |
|             | Noninfectious causes: nutritional secondary hyperparathyroidism, trauma, malnutrition (e.g., hypovitaminosis B), thiaminosis, hypervitaminosis D, gout, xanthomatosis/hyperlipidosis, toxicosis (especially insecticides), neoplasia, drug reaction                                                                                                                                                                                        |                                                                                                                                                                                                                                                                                                                                                 |
| Spindly leg | Infectious agents: iridovirus, larval cestodes or trematodes, subcutaneous nematodes                                                                                                                                                                                                                                                                                                                                                       | Biology review of species in question; husbandry review (water quality tests, temperature); diet (inspect actual food items and supplements in original                                                                                                                                                                                         |
|             | Noninfectious causes: nutritional secondary hyperparathyroidism, malnutrition (e.g.,                                                                                                                                                                                                                                                                                                                                                       |                                                                                                                                                                                                                                                                                                                                                 |

hypovitaminosis B, protein deficiency, iodine deficiency, trace mineral deficiency, diet of parents, outdated food or vitamin supplements), toxicosis (ammonia, chlorine, nitrites), water quality (pH, hardness, temperature), crowding, poor illumination, trauma, genetic, hybridization

containers); PCR tests for ranavirus and chytrid; necropsy of dead specimens; physical exam of cagemates and parents; consider euthanasia and complete necropsy of one or more cagemates

<sup>a</sup> This is based on the author's (K.W.) clinical impressions of the most common underlying etiologies for gross symptomology; a patient's differential list should be a comprehensive review of all potential etiologies regardless of likelihood.

<sup>b</sup> Suggested diagnostics are presented in prioritized order.

TABLE 3-9 Suggested Disinfectants Proven to Eliminate Chytridiomycosis from Equipment and Cage Furniture.<sup>28</sup>

- Rinse with 1% sodium hypochlorite (household bleach)
- Exposure for 20 sec to 70% ethanol
- Exposure for 20 sec to 1 mg/mL benzalkonium chloride
- Desiccation and exposure to 50-60°C (122-140°F) heat for 30 min
- Exposure to 0.008 percent quaternary ammonium compound Quat-128 (Waxie Sanitary Supply, San Diego, CA; 800-995-4466; [www.waxie.com](http://www.waxie.com)); this contains 6.8% didecyl dimethyl ammonium chloride (DDAC) as the active ingredient

TABLE 3-10 Guidelines for Managing Pet Amphibians with Nematode Parasites.<sup>53</sup>

- Determine purpose of captive amphibian
  - Pet amphibians are often kept for different purposes than captive assurance colonies
  - Plan must be with owner's informed consent
- Assess current health and body condition score (BCS)
  - If unthrifty

- Consider any nematode ova, larvae, or adults significant
- If well-fleshed, score the fecal parasite exam
  - If diarrhea, blood, mucus, or visible nematodes are present at any stage of the fecal parasite examination, treat
  - If stool appears normal
    - and there are  $\leq 5$  RBC/HPF or  $< 1$  WBC/HPF, parasites may not be significant
    - and there are  $> 5$ -10 RBC/HPF or  $> 1$ -5 WBC/HPF, parasites are likely significant
    - or there are  $> 5$  strongyle larvae/HPF on direct or float, treat
- Treatment of amphibians that are apparently healthy, have normal appetites, and are eating well and maintaining or gaining weight, should be done with caution despite the presence of a few nematode ova or larvae per high-power field on direct or flotation fecal parasite exams.
  - If any amphibians in the collection appear unthrifty, there are mortalities with nematodes implicated, or there are otherwise unexplained mortalities, treat for nematodes.
  - Monitor with regular direct fecal parasite exams to evaluate a shift in cytology and fluctuations in nematode ova and larvae; while there is often no correlation between reduction in nematode ova or larvae in feces and actual reduction in nematode numbers, improvements in BCS and weight often happen when the ova or larvae counts go down and the feces has  $\leq 5$  RBC/HPF and  $< 1$  WBC/HPF.
    - Success is measured by an amphibian having a normal weight and BCS, producing normal-appearing feces, and exhibiting normal behaviors.
    - With problematic pets, randomly collected feces should be assessed for parasites.

TABLE 3-11 Amphibian Quarantine Protocols.

Because of worldwide amphibian population declines and local extinctions, assurance colonies are being brought into captivity in hopes of preserving species for the future. The importance of these assurance colonies, and the possibility of future reintroduction efforts, makes proper quarantine and infectious disease testing paramount. In most cases, amphibians destined for use in reintroduction programs should remain in permanent quarantine to prevent introduction of novel pathogens. A 30-day quarantine is the minimum suggested time for quarantine of low risk amphibians, and moderate to high risk animals should be quarantined for 60-90 days. Release from quarantine is predicated on interpretation of morbidity and mortality, appropriate testing to detect important diseases, and a healthy body condition score and normal physical examination prior to release. Any quarantine plan must have the owner’s informed consent before implementation.

**Husbandry**

- Facilities and equipment
  - Ideally, each quarantine area is spatially separated from areas containing other animals. In addition, separate air-handling systems should exist for individual areas. Tools should be designated for use only in quarantine areas. Some facilities may employ shower-in/shower-out protocols, but at the very least boots, smocks/coveralls should be worn when servicing quarantine animal areas.
- Enclosures
  - Enclosures should be escape-proof and made of non-abrasive, non-toxic material. Enclosures with spartan furnishings are easiest to monitor and maintain in quarantine situations; however, many

animals will not thrive in such conditions. Critical husbandry requirements should always take precedent over other needs.

- Food
  - Transmission of infectious disease through food animals is possible. In cases where this is of significant concern, it may be prudent to establish on-site breeding colonies and occasionally screen for various pathogens.

**Quarantine Examination**

- Physical examination can be facilitated via manual restraint, restraint in a clear container, or via anesthesia.
- It is important to individually identify animals maintained in groups. Microchips and subcutaneous polymers can be placed; however, retention can be a problem. Charting of characteristic colors/patterns can be useful in some species. Although toe-clipping has been used as a last resort, it's not recommended because of humane and health reasons.
- Body weight and body condition scores should be assessed on arrival, periodically throughout quarantine, and immediately prior to release.

**Diagnostic Testing**

- Fecal flotation and direct examination
  - It may be difficult to obtain diagnostic fecal samples from many amphibians because of their small size. Quality samples can be obtained by placing the animal in a small container lined with damp, plain paper toweling overnight following a meal. It is best to assume wild amphibians are parasitized even though fecal exams are often negative for the presence of parasites or ova.
- Complete blood count and chemistry panel
  - A large percentage of amphibians are too small to safely take routine blood samples. Even larger specimens can present venipuncture challenges. Cardiac puncture or venipuncture of the ventral abdominal vein in an anesthetized animal usually produces the best samples with the highest degree of safety. Normal ranges for bloodwork parameters are not available for the vast majority of species which creates interpretive challenges.
- Specific infectious disease testing
  - It is paramount that amphibians entering quarantine be screened for chytridiomycosis and ranavirus infection. Polymerase chain reaction tests are available for both pathogens, although chytrid fungus can also be detected via cytology of skin scrapings. Other specific pathogen testing will depend on individual circumstances.

**Prophylactic Treatment**

- Fluid therapy



- Newly captured or shipped amphibians can be stressed and dehydrated. Amphibian Ringer’s solution (see [Table 3-6](#)) can be used as a bath to help hydrate the animal and replenish solutes.
- Deworming
  - It is impractical to impossible to completely clear most amphibians of parasites. However, treatment to decrease the numbers of parasites can be critical in acclimating some animals to captivity. Treatment should address the results of diagnostic testing, otherwise empirical therapy with broad-spectrum anthelmintics is recommended.
- Treatment for chytridiomycosis
  - Animals brought into captivity from areas suffering local declines due to chytridiomycosis should always be prophylactically treated. In other situations, it is recommended to avoid treatment unless an infection is diagnosed to avoid development of resistance to available drugs.

**Maintenance and Hygiene**

- A variety of disinfectants are available for use in amphibian applications. Care should be taken to choose a product that meets the disinfection needs but is not unsafe for the amphibians.
- Heat, dessication, and ultraviolet light can be used, in some cases, to disinfect equipment and materials without the hazards associated with chemical use.
- Proper disposal of solid waste/water is important to avoid exposure of native amphibians in the area to novel pathogens. At the least, waste water should only be discarded into a sanitary sewer and solid waste be deeply buried or transferred to a landfill. Best practices involve treating all waste that comes in contact with quarantined amphibians as potential biohazardous waste and disposing of accordingly. Waste water and other materials should never be discarded into the environment in a manner where exposure to native amphibians is likely.

**Infectious Disease Screening**

There are a number of laboratories that will perform various tests to document exposure to or presence of chytrid fungus or ranavirus particles via PCR. It is up to the clinician to evaluate the tests run by the various laboratories and interpret the results accordingly. The following are contact information for laboratories that perform ranavirus and/or chytrid testing. This list is by no means conclusive, and contact information was verified as of December 31, 2010.

*Amphibian Disease Laboratory*  
  
San Diego Zoo Institute for Conservation Research  
  
15600 San Pasqual Valley Rd.  
  
Escondido, CA 92027, USA  
  
760-747-8702 Ext. 5471

[www.sandiegozoo.org/conservation/news/Amphibian\\_Disease\\_Laboratory/](http://www.sandiegozoo.org/conservation/news/Amphibian_Disease_Laboratory/)

Chytridiomycosis and ranavirus

*Pisces Molecular*

1600 Range St., Suite 201

Boulder, CO 80301, USA

303-546-9300

[www.pisces-molecular.com](http://www.pisces-molecular.com)

Chytridiomycosis

*Research Associates Laboratory*

14556 Midway Road

Dallas, TX 75244, USA

972-960-2221

[www.vetdna.com](http://www.vetdna.com)

Chytridiomycosis

*Zoologix*

9811 Owensmouth Ave., Suite 4

Chatsworth, CA 91311, USA

818-717-8880

[www.zoologix.com](http://www.zoologix.com)

Chytridiomycosis, ranavirus, and various *Mycobacterium* species

## References<sup>a</sup>

1. Anver MR, Pond CL. Biology and diseases of amphibians. In: Fox JG, Cohen BJ, Loew FM. *Laboratory Animal Medicine*. Orlando: Academic Press; 1984:427–447.

2. Bishop PJ, Spear R, Poulet R, et al. Elimination of the amphibian chytrid fungus *Batrachochytrium dendrobatidis* by Archey's frog *Leiopelma archeyi*. *Dis Aquat Org*. 2009;84:9–15.
3. Burns RB, McMahan W. Euthanasia methods for ectothermic vertebrates. In: Bonagura JD, ed. *Kirk's Current Veterinary Therapy XII: Small Animal Practice*. Philadelphia: WB Saunders Co; 1995:1379–1381.
4. Campbell TW. Amphibian husbandry and medical care. In: Rosenthal KL, ed. *Practical Exotic Animal Medicine (Compendium collection)*. Trenton: Veterinary Learning Systems; 1997:65–68.
5. Cooper JE. Anesthesia of exotic animals. *Anim Technol*. 1984;35:13–20.
6. Crawshaw GJ. Amphibian medicine. In: Kirk RW, Bonagura JD. *Kirk's Current Veterinary Therapy XI: Small Animal Practice*. Philadelphia: WB Saunders Co; 1992:1219–1230.
7. Crawshaw GJ. Amphibian medicine. In: Fowler ME, ed. *Zoo & Wild Animal Medicine: Current Therapy 3*. Philadelphia: WB Saunders Co; 1993:131–139.
8. Crawshaw GJ. Amphibian emergency and critical care. *Vet Clin North Am Exotic Anim Pract*. 1998;1:207–231.
9. D'Agostino JJ, West G, Boothe DM, et al. Plasma pharmacokinetics of selamectin after a single topical administration in the American bullfrog (*Rana catesbeiana*). *J Zoo Wildl Med*. 2007;38:51–54.
10. Downes H. Tricaine anesthesia in amphibia. a review. *Bull Assoc Rept Amph Vet*. 1995;5:11–16.
11. El-Mofty MM, Abdelmeguid NE, Sadek IA, et al. Induction of leukaemia in chloramphenicol-treated toads. *E Mediter Health J*. 2000;6:1026–1034.
12. Fox WF. Treatment and dosages. *Axolotl Newsl*. 1980;9:6.
13. Graczyk TK, Cranfield MR, Bichnese EJ, et al. Progressive ulcerative dermatitis in a captive wild-caught South American giant treefrog (*Phyllomedusa*

bicolor) with microsporidial septicemia. *J Zoo Wildl Med*. 1996;27:522–527.

14. Iglauer F, Willmann F, Hilken G, et al. Anthelmintic treatment to eradicate cutaneous capillariasis in a colony of South African clawed frogs (*Xenopus laevis*). *Lab Anim Sci*. 1997;47:477–482.

15. Jacobson E, Kollias GV, Peters LJ. Dosages for antibiotics and parasiticides used in exotic animals. *Compend Contin Educ Pract Vet*. 1983;5:315–324.

16. Johnson JH. Anesthesia, analgesia and euthanasia of reptiles and amphibians. *Proc Annu Meet Am Assoc Zoo Vet*. 1991:132–138.

17. Kouba A. Personal communication; 2009.

18. Lafortune M, Mitchell MA, Smith JA. Evaluation of clinical and cardiopulmonary effects of clove oil (eugenol) on leopard frogs, *Rana pipiens*. *Proc Annu Conf Assoc Rept Amph Vet*. 2000:51–53.

19. Letcher J. Evaluation of use of tiletamine/zolazepam for anesthesia of bullfrogs and leopard frogs. *J Am Vet Med Assoc*. 1995;207:80–82.

20. Letcher J, Glade M. Efficacy of ivermectin as an anthelmintic in leopard frogs. *J Am Vet Med Assoc*. 1992;200:537–538.

21. Letcher J, Papich M. Pharmacokinetics of intramuscular administration of three antibiotics in bullfrogs (*Rana catesbeiana*). *Proc Annu Conf Assoc Rept Amph Vet/Am Assoc Zoo Vet*; 1994:79–93.

22. Machin KL. Amphibian pain and analgesia. *J Zoo Wildl Med*. 1999;30:2–10.

23. Maruska EJ. Procedures for setting up and maintaining a salamander colony. In: Murphy JB, Adler K, Collins JT. *Captive Management and Conservation of Amphibians and Reptiles*. Ithaca: Society for the Study of Amphibians and Reptiles; 1994:229–242.

24. Menard MR. External application of antibiotic to improve survival of adult laboratory frogs (*Rana pipiens*). *Lab Anim Sci*. 1984;34:94–96.

25. Mitchell MA, Riggs SM, Singleton CB, et al. Evaluating the clinical and cardiopulmonary effects of clove oil and propofol in tiger salamanders (*Ambystoma tigrinum*). *J Exotic Pet Med*. 2009;18:50–56.
26. Mombarg M, Claessen H, Lambrechts L, et al. Quantification of percutaneous absorption of metronidazole and levamisole in the fire-bellied toad (*Bombina orientalis*). *J Vet Pharmacol Therap*. 1992;15:433–436.
27. Nichols DK, Lamirander EW, Pessier AP, et al. Experimental transmission and treatment of cutaneous chytridiomycosis in poison dart frogs (*Dendrobates auratus* and *Dendrobates tinctorius*). *Proc Annu Conf Am Assoc Zoo Vet/Internat Assoc Aquatic Anim Med*; 2000:42–44.
28. Pessier AP, Mendelson JR. A Manual for Control of Infectious Diseases in Amphibian Survival Assurance Colonies and Reintroduction Programs. Apple Valley, MN: IUCN/SSC Conservation Breeding Specialist Group, December 31, 2010. Available at [www.cbsg.org/cbsg/workshopreports/26/amphibian\\_disease\\_manual.pdf](http://www.cbsg.org/cbsg/workshopreports/26/amphibian_disease_manual.pdf) Accessed
29. Poulter R, Bishop P, Speare R. A protocol for treating chytrid (*Batrachochytrium dendrobatidis*)-infected frogs. Available at [www.nzfrogs.org/site/nzfrog/files/Treatment%20Protocol.pdf](http://www.nzfrogs.org/site/nzfrog/files/Treatment%20Protocol.pdf), December 31, 2010. Accessed
30. Poynton SL, Whitaker BR. Protozoa in poison dart frogs (*Dendrobatidae*). clinical assessment and identification. *J Zoo Wildl Med*. 1994;25:29–39.
31. Raphael BL. Amphibians. *Vet Clin North Am Small Anim Pract*. 1993;23:1271–1286.
32. Rowson AD, Obringer AR, Roth TL. Non-invasive treatments of luteinizing hormone-releasing hormone for inducing spermiation in American (*Bufo americanus*) and Gulf Coast (*Bufo valliceps*) toads. *Zoo Biol*. 2001;20:63–74.
33. Schumacher J. Reptiles and amphibians. In: Lumb WV, Jones EW. *Veterinary Anesthesia*. 2nd ed. Philadelphia: Williams & Wilkins; 1996:670–685.

34. Shilton CM, Smith DA, Crawshaw GJ, et al. Corneal lipid deposition in Cuban tree frogs (*Osteopilus septentrionalis*) and its relationship to serum lipids. an experimental study. *J Zoo Wildl Med*. 2001;32:305–319.
35. Stein G. Reptile and amphibian formulary. In: Mader DR, ed. *Reptile Medicine and Surgery*. Philadelphia: WB Saunders Co; 1996:465–472.
36. Stetter MD, Raphael B, Indiviglio F, et al. Isoflurane anesthesia in amphibians. comparison of five application methods. *Proc Annu Conf Am Assoc Zoo Vet*. 1996:255–257.
37. Stoskopf MK. Pain and analgesia in birds, reptiles, amphibians, and fish. *Invest Ophthalmol Visual Sci*. 1994;35:775–780.
38. Stoskopf MK, Arnold J, Mason M. Aminoglycoside antibiotic levels in the aquatic salamander (*Necturus necturus*). *J Zoo Anim Med*. 1987;18:81–85.
39. Teare JA, Wallace RS, Bush M. Pharmacology of gentamicin in the leopard frog (*Rana pipiens*). *Proc Annu Conf Am Assoc Zoo Vet*. 1991:128–131.
40. Verrel PA. Hormonal induction of ovulation and oviposition in the salamander *Desmognathus ochrophaeus* (Plethodontidae). *Herp Rev*. 1989;20:42–43.
41. von Esse FV, Wright KM. Effect of intracoelomic propofol in White's tree frogs, *Pelodytes caerulea*. *Bull Assoc Rept Amph Vet*. 1999;9:7–8.
42. Whitaker BR. Developing an effective quarantine program for amphibians. *Proc North Am Vet Conf*. 1997:764–765.
43. Whitaker BR. Reproduction. In: Wright KM, Whitaker BR. *Amphibian Medicine and Captive Husbandry*. Malabar, FL: Krieger Publishing Co; 2001:285–299.
44. Whitaker BR, Wright KM, Barnett SL. Basic husbandry and clinical assessment of the amphibian patient. *Vet Clin North Am Exotic Anim Pract*. 1999;2:265–290.
45. Willette-Frahm M, Wright KM, Thode BC. Select protozoan diseases in

amphibians and reptiles. *Bull Assoc Rept Amph Vet.* 1995;5:19–29.

46. Williams DL. Amphibians. In: Beynon PH, Cooper JE. *BSAVA Manual of Exotic Pets*. Gloucestershire: British Small Animal Veterinary Association; 1991:261–271.

47. Williams DL. Amphibian dermatology. In: Bonagura JD, ed. *Kirk's Current Veterinary Therapy XII: Small Animal Practice*. Philadelphia: WB Saunders Co; 1995:1375–1379.

48. Williams DL, Whitaker BR. The amphibian eye—a clinical review. *J Zoo Wildl Med.* 1994;25:18–28.

49. Woodhams DC, Alford RA, Marantelli G. Emerging disease of amphibians cured by elevated body temperature. *Dis Aquat Org.* 2003;55:65–67.

50. Wright KM. Chlamydial infections of amphibians. *Bull Assoc Rept Amph Vet.* 1996;6:8–9.

51. Wright KM. Trauma. In: Wright KM, Whitaker BR. *Amphibian Medicine and Captive Husbandry*. Malabar, FL: Krieger Publishing Co; 2001:233–238.

52. Wright KM. Amphibian formulary. In: Mader DR, ed. *Reptile Medicine and Surgery*. 2nd ed. St Louis: Saunders/Elsevier; 2006:1140–1146.

53. Wright KM. Personal observation; 2011.

54. Wright KM, Whitaker BR. Pharmacotherapeutics. In: Wright KM, Whitaker BR. *Amphibian Medicine and Captive Husbandry*. Malabar, FL: Krieger Publishing Co; 2001:309–330.

<sup>a</sup> Note: Pessier AP, Mendelson JR<sup>28</sup> is an important and convenient source of information on amphibian medicine and is available free online.

# Chapter 4

## Reptiles

Paul M. Gibbons, Eric Klaphake, James W. Carpenter

For ease of use for the reptile chapter, drug dosages are first listed by “most species,” followed by dosages in snakes, lizards, chelonians, and crocodilians; feed and water dosages are generally listed last.

TABLE 4-1 Antimicrobial Agents Used in Reptiles. [a](#), [b](#)

| Agent       | Dosage                                                                       | Species/Comments                                                                                                                                         |
|-------------|------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------|
| Amikacin    | —                                                                            | Potentially nephrotoxic; maintain hydration; frequently used with a penicillin or cephalosporin                                                          |
|             | 26 µg/kg/hr via osmotic infusion pump implant <sup><a href="#">295</a></sup> | Corn snakes/PD; 1.7 mg/kg IM loading dose at time of implant                                                                                             |
|             | 3.48 mg/kg IM once <sup><a href="#">151</a></sup>                            | Pythons/PD (ball pythons)                                                                                                                                |
|             | 5 mg/kg IM, then 2.5 mg/kg q72h <sup><a href="#">192</a></sup>               | Gopher snakes/PD; house at high end of optimum temperature range during treatment                                                                        |
|             | 5 mg/kg IM, then 2.5 mg/kg q72h <sup><a href="#">10,286</a></sup>            | Lizards                                                                                                                                                  |
|             | 2.5-3 mg/kg IM q72h × 5 treatments <sup><a href="#">304</a></sup>            | Sea turtles                                                                                                                                              |
|             | 5 mg/kg IM q48h <sup><a href="#">35</a></sup>                                | Gopher tortoises/PD; 30°C (86°F)                                                                                                                         |
|             | 2.25 mg/kg IM q72h <sup><a href="#">140</a></sup>                            | Alligators/PD                                                                                                                                            |
|             | 50 mg/10 mL saline × 30 min nebulization q12h <sup><a href="#">96</a></sup>  | Most species/pneumonia; aminophylline at 25 mg/9 mL of sterile saline in nebulizer before antibiotics for bronchodilation <sup><a href="#">253</a></sup> |
| Amoxicillin | 10 mg/kg IM q24h <sup><a href="#">62</a></sup>                               | Most species/use with an aminoglycoside                                                                                                                  |
|             | 22 mg/kg PO q12-24h <sup><a href="#">64,83</a></sup>                         | Most species/use with an aminoglycoside                                                                                                                  |
| Ampicillin  | —                                                                            | May use with an aminoglycoside                                                                                                                           |



|                                |                                                                               |                                                                                                                                                                                                                                                              |
|--------------------------------|-------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                                | 3-6 mg/kg PO, SC, IM q12-24h <sup><a href="#">83,92</a></sup>                 | Most species                                                                                                                                                                                                                                                 |
|                                | 10-20 mg/kg SC, IM q12h <sup><a href="#">144</a></sup>                        | Most species, including chameleons                                                                                                                                                                                                                           |
|                                | 20 mg/kg IM q24h <sup><a href="#">243</a></sup>                               | Chelonians                                                                                                                                                                                                                                                   |
|                                | 50 mg/kg IM q12h <sup><a href="#">86,280</a></sup>                            | Tortoises                                                                                                                                                                                                                                                    |
| Azithromycin                   | 10 mg/kg PO q2-7d <sup><a href="#">48</a></sup>                               | Ball pythons/PD; single dose study; may cause nonregenerative anemia; <i>Mycoplasma</i> , <i>Cryptosporidium</i> , <i>Giardia</i> and other susceptible organisms; location dictates dosage frequency: skin, q3d; respiratory tract, q5d; liver/kidneys, q7d |
| Carbenicillin                  | 200 mg/kg IM q24h <sup><a href="#">128</a></sup>                              | Carpet pythons/PD                                                                                                                                                                                                                                            |
|                                | 400 mg/kg IM q24h <sup><a href="#">172</a></sup>                              | Snakes/PD; 30°C (86°F)                                                                                                                                                                                                                                       |
|                                | 400 mg/kg SC, IM q24h <sup><a href="#">10</a></sup>                           | Lizards/may use with an aminoglycoside (administer at different time of day)                                                                                                                                                                                 |
|                                | 200-400 mg/kg IM q48h <sup><a href="#">243</a></sup>                          | Chelonians/may use with an aminoglycoside; may cause skin sloughing in desert tortoises; fluid therapy recommended                                                                                                                                           |
|                                | 400 mg/kg IM q48h <sup><a href="#">171</a></sup>                              | Chelonians/PD ( <i>Testudo</i> spp)                                                                                                                                                                                                                          |
| Cefoperazone (Cefobid, Pfizer) | 100 mg/kg IM q96h <sup><a href="#">86</a></sup>                               | Snakes/PD (false water cobras; 24°C [75°F])                                                                                                                                                                                                                  |
|                                | 125 mg/kg IM q24h <sup><a href="#">86</a></sup>                               | Lizards/PD (tegus; 24°C [75°F])                                                                                                                                                                                                                              |
| Cefotaxime                     | 20-40 mg/kg IM q24h <sup><a href="#">92,243</a></sup>                         | Most species/may use with an aminoglycoside                                                                                                                                                                                                                  |
|                                | 100 mg/10 mL saline × 30 min nebulization q24h <sup><a href="#">226</a></sup> | Most species/pneumonia                                                                                                                                                                                                                                       |
| Ceftazidime                    | 20-40 mg/kg SC, IM, q48-72h <sup><a href="#">86,286,305</a></sup>             | Most species/in chameleons use q24h                                                                                                                                                                                                                          |
|                                | 20 mg/kg SC, IM, IV q72h <sup><a href="#">10,170</a></sup>                    | Snakes/PD; 30°C (86°F); especially effective against gram-negative aerobes (i.e., <i>Pseudomonas</i> )                                                                                                                                                       |

|                                            |                                                                                                      |                                                                                                                                     |
|--------------------------------------------|------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------|
|                                            | 22 mg/kg IM, IV<br>q72h <sup><a href="#">289</a></sup>                                               | Sea turtles                                                                                                                         |
| Ceftiofur sodium                           | 2.2 mg/kg IM<br>q48h <sup><a href="#">64</a></sup>                                                   | Snakes                                                                                                                              |
|                                            | 5 mg/kg SC, IM<br>q24h <sup><a href="#">20</a></sup>                                                 | Lizards/PD (green iguanas)                                                                                                          |
|                                            | 2.2 mg/kg IM<br>q24h <sup><a href="#">64</a></sup>                                                   | Turtles                                                                                                                             |
|                                            | 4 mg/kg IM<br>q24h <sup><a href="#">64,92</a></sup>                                                  | Tortoises/upper respiratory infection                                                                                               |
| Cefuroxime                                 | 100 mg/kg IM<br>q24h <sup><a href="#">64,92</a></sup>                                                | Most species, including snakes/30°C (86°F);<br>may use with an aminoglycoside                                                       |
| Cephalexin                                 | 20-40 mg/kg PO<br>q12h <sup><a href="#">86</a></sup>                                                 | Most species/unknown absorption                                                                                                     |
| Cephalothin                                | 20-40 mg/kg IM<br>q12h <sup><a href="#">86,92,291</a></sup>                                          | Most species                                                                                                                        |
| Chloramphenicol                            | —                                                                                                    | Most species/public health concern; reserve<br>for meningitis or encephalitis caused by<br>susceptible organisms                    |
|                                            | 40 mg/kg PO, SC,<br>IM q24h, or 20<br>mg/kg PO, SC, IM<br>q12h <sup><a href="#">86,143,243</a></sup> | Most species/20 mg/kg may be given q24h in<br>larger crocodilians                                                                   |
|                                            | 40 mg/kg SC<br>q24h <sup><a href="#">33</a></sup>                                                    | Snakes/PD (gopher snakes, 29°C [84°F])                                                                                              |
|                                            | 50 mg/kg SC q12-<br>72h <sup><a href="#">45,86</a></sup>                                             | Snakes/PD; q12h in indigo, rat, king snakes;<br>q24h in boids, moccasins; q48h in<br>rattlesnakes; q72h in red-bellied water snakes |
| Chlorhexidine (Nolvasan 2%,<br>Fort Dodge) | Topical 0.05%<br>aqueous solution<br>q24h <sup><a href="#">212</a></sup>                             | All species/topical disinfection; dermatitis;<br>infectious stomatitis; periodontal disease in<br>lizards q24h                      |
|                                            | 1:30 solution <sup><a href="#">28,225</a></sup>                                                      | Most species/topical disinfection; infectious<br>stomatitis; abscess lavage; middle ear<br>infection flush in box turtles           |
| Chlortetracycline                          | 200 mg/kg PO<br>q24h <sup><a href="#">86,291</a></sup>                                               | Most species                                                                                                                        |
| Ciprofloxacin (Cipro, Bayer)               | 10 mg/kg PO<br>q48h <sup><a href="#">64</a></sup>                                                    | Most species                                                                                                                        |
|                                            | 11 mg/kg PO q48-<br>72h <sup><a href="#">160</a></sup>                                               | Pythons/PD (reticulated pythons)                                                                                                    |
| Ciprofloxacin ophthalmic                   |                                                                                                      |                                                                                                                                     |

|                                    |                                                                       |                                                                                                                                                                    |
|------------------------------------|-----------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| ointment or drops (Ciloxan, Alcon) | Topical <sup><a href="#">189</a></sup>                                | All species/infectious stomatitis; gingivitis                                                                                                                      |
| Clarithromycin                     | 15 mg/kg PO q48-72h <sup><a href="#">148,308</a></sup>                | Tortoises/PD (desert tortoises); upper respiratory tract disease (mycoplasmosis)                                                                                   |
| Clindamycin                        | 5 mg/kg PO q12h <sup><a href="#">291</a></sup>                        | Most species/gram-positive bacteria and anaerobes                                                                                                                  |
| Danofloxacin                       | 6 mg/kg SC, IM <sup><a href="#">197</a></sup>                         | Loggerhead sea turtles                                                                                                                                             |
|                                    | 6 mg/kg SC q48h × 30 days <sup><a href="#">190</a></sup>              | Tortoises/mycoplasmosis                                                                                                                                            |
| Dihydrostreptomycin                | 5 mg/kg IM q12-24h <sup><a href="#">83,291</a></sup>                  | Most species/maintain hydration                                                                                                                                    |
| Doxycycline (Vibramycin, Pfizer)   | 5-10 mg/kg PO q24h × 10-45 days <sup><a href="#">143,291</a></sup>    | Most species/respiratory infection (i.e., mycoplasmosis)                                                                                                           |
|                                    | 50 mg/kg IM, then 25 mg/kg q72h <sup><a href="#">31,280</a></sup>     | Tortoises/Hermann's tortoise 27°C (81°F)                                                                                                                           |
| Enrofloxacin (Baytril, Bayer)      | 5-10 mg/kg q24h PO, SC, IM, ICe <sup><a href="#">291</a></sup>        | Most species/IM administration is painful and may result in tissue necrosis and sterile abscesses; may cause skin discoloration or tissue necrosis if given SC     |
|                                    | 6.6 mg/kg IM q24h, or 11 mg/kg IM q48h <sup><a href="#">160</a></sup> | Pythons/PD (reticulated pythons); <i>Pseudomonas</i>                                                                                                               |
|                                    | 10 mg/kg IM q48h <sup><a href="#">315</a></sup>                       | Snakes/PD (Burmese pythons); <i>Pseudomonas</i>                                                                                                                    |
|                                    | 5 mg/kg PO, IM q24h <sup><a href="#">205</a></sup>                    | Lizards/PD (green iguanas); marked pharmacokinetic variability with PO administration may make IM more suitable in critically ill animals                          |
|                                    | 10 mg/kg IM q5d <sup><a href="#">130</a></sup>                        | Monitors/PD (savannah monitors); preliminary data                                                                                                                  |
|                                    | 5 mg/kg IM q24-48h <sup><a href="#">249</a></sup>                     | Chelonians and most other reptiles/PD (gopher tortoises); hyperexcitation, incoordination, diarrhea reported in a Galapagos tortoise <sup><a href="#">39</a></sup> |
|                                    | 5 mg/kg IM q12-24h <sup><a href="#">257</a></sup>                     | Chelonians/PD (Indian star tortoises); q12h for <i>Pseudomonas</i> and <i>Citrobacter</i> ; q24h for other bacteria                                                |
|                                    | 5 mg/kg IM q48h <sup><a href="#">304</a></sup>                        | Sea turtles                                                                                                                                                        |
|                                    | 10 mg/kg IM                                                           |                                                                                                                                                                    |

|                                                                                |                                                                                             |                                                                                                                                                   |
|--------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------|
|                                                                                | q24h <sup><a href="#">280</a></sup>                                                         | Chelonians/PD (Hermann's tortoises)                                                                                                               |
|                                                                                | 5 mg/kg IV q36-72h <sup><a href="#">117,200</a></sup>                                       | Crocodylians/PD; PO pharmacokinetics not fully determined; mycoplasmosis                                                                          |
|                                                                                | Nasal flush 50 mg/250 mL sterile water; 1-3 mL/naris q24-48h <sup><a href="#">143</a></sup> | Tortoises/URT syndrome; use until no more discharge (5-10 days); may use concurrently with parenteral antibiotics                                 |
| Gentamicin                                                                     | —                                                                                           | Nephrotoxicity has been reported, <sup><a href="#">223</a></sup> especially in snakes; maintain hydration; use with a penicillin or cephalosporin |
|                                                                                | 2.5 mg/kg IM q72h <sup><a href="#">33,34</a></sup>                                          | Snakes/PD (gopher snakes)                                                                                                                         |
|                                                                                | 2.5-3 mg/kg IM, then 1.5 mg/kg q96h <sup><a href="#">125</a></sup>                          | Snakes/PD (blood pythons)                                                                                                                         |
|                                                                                | 3 mg/kg IM q>96h <sup><a href="#">11</a></sup>                                              | Turtles/PD (eastern box turtles; 29°C [84°F]); lower dose may be more appropriate                                                                 |
|                                                                                | 5 mg/kg IM q72h <sup><a href="#">243</a></sup>                                              | Chelonians                                                                                                                                        |
|                                                                                | 6 mg/kg IM q72-96h <sup><a href="#">255</a></sup>                                           | Turtles/PD (red-eared sliders; 24°C [75°F])                                                                                                       |
|                                                                                | 1.75-2.25 mg/kg IM q72-96h <sup><a href="#">140</a></sup>                                   | Crocodylians/PD (alligators); respiratory infection                                                                                               |
| Gentamicin ophthalmic ointment or drops                                        | Topical <sup><a href="#">83</a></sup>                                                       | Most species/superficial ocular infection; lesions in oral cavity                                                                                 |
| Gentamicin/betamethasone ophthalmic drops (Gentocin Durafilm, Schering-Plough) | 1-2 drops to eye q12-24h <sup><a href="#">148</a></sup>                                     | Tortoises/upper respiratory infections; may also be given as a reverse nasal flush q48-72h or intranasal q12-24h                                  |
| Kanamycin                                                                      | 10-15 mg/kg IM, IV q24h (or divided doses) <sup><a href="#">64,83</a></sup>                 | Most species/24°C (75°F); give with fluid therapy; avoid in cases of dehydration or renal or hepatic dysfunction                                  |
| Lincomycin                                                                     | 5 mg/kg IM q12-24h <sup><a href="#">64</a></sup>                                            | Most species/wound infection; potentially nephrotoxic; maintain hydration                                                                         |
|                                                                                | 10 mg/kg PO q24h <sup><a href="#">64</a></sup>                                              | Most species                                                                                                                                      |
| Marbofloxacin                                                                  | 10 mg/kg PO q48h <sup><a href="#">49</a></sup>                                              | Ball pythons/PD                                                                                                                                   |
| Metronidazole                                                                  | 20 mg/kg PO q48h × ≥7 days <sup><a href="#">87</a></sup>                                    | Most species/anaerobes                                                                                                                            |
|                                                                                |                                                                                             | Most species/may be administered concurrently with amikacin for broader                                                                           |

|                                                                 |                                                                                        |                                                                                                                             |
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|                                                                 | 50 mg/kg PO q24h<br>× 7-14 days <sup><a href="#">160</a></sup>                         | spectrum; because of potential side effects at this dose, a lower dose may be prudent                                       |
|                                                                 | 20 mg/kg PO<br>q48h <sup><a href="#">25,167</a></sup>                                  | Snakes/PD (corn and rat snakes)                                                                                             |
|                                                                 | 20 mg/kg PO q24-<br>48h <sup><a href="#">168</a></sup>                                 | Iguanas/PD; use q24h for resistant anaerobes                                                                                |
| Oxytetracycline                                                 | 6-10 mg/kg PO, IM,<br>IV q24h <sup><a href="#">64,83</a></sup>                         | Most species/may produce local inflammation at injection site                                                               |
|                                                                 | 5-10 mg/kg IM<br>q24h <sup><a href="#">148</a></sup>                                   | Tortoises/upper respiratory tract infection (mycoplasmosis)                                                                 |
|                                                                 | 10 mg/kg IM, IV<br>q5d <sup><a href="#">116</a></sup>                                  | Crocodilians/PD (alligators; 27°C [81°F]); mycoplasmosis                                                                    |
| Penicillin, benzathine                                          | 10,000-20,000 U/kg<br>IM q48-96h <sup><a href="#">86</a></sup>                         | Most species/may use with an aminoglycoside                                                                                 |
| Penicillin G                                                    | 10,000-20,000 U/kg<br>SC, IM, IV, ICe q8-<br>12h <sup><a href="#">83</a></sup>         | Most species/infrequently used                                                                                              |
| Piperacillin                                                    | 50-100 mg/kg IM<br>q24h <sup><a href="#">64,83</a></sup>                               | Most species/broad-spectrum bactericidal agent; maintain hydration; may use with an aminoglycoside                          |
|                                                                 | 50 mg/kg IM, then<br>25 mg/kg<br>q24h <sup><a href="#">64,291</a></sup>                | Snakes                                                                                                                      |
|                                                                 | 100 mg/kg IM<br>q48h <sup><a href="#">126</a></sup>                                    | Snakes/PD (blood pythons)                                                                                                   |
|                                                                 | 100-200 mg/kg SC,<br>IM q24-48h <sup><a href="#">144</a></sup>                         | Chameleons                                                                                                                  |
|                                                                 | 100 mg/10 mL<br>saline × 30 min<br>nebulization<br>q12h <sup><a href="#">226</a></sup> | Most species/pneumonia                                                                                                      |
| Polymyxin B sulfate, neomycin sulfate, bacitracin zinc ointment | Topical <sup><a href="#">96</a></sup>                                                  | All species/rostral abrasions, dermal wounds                                                                                |
| Povidone-iodine solution (0.05%) or ointment                    | Topical/lavage <sup><a href="#">83,239</a></sup>                                       | All species/fungal dermatitis; dermatophilosis; contaminated wound; can soak in 0.005% aqueous solution ≤1 hr q12-24h       |
| Silver sulfadiazine cream (Silvadene, Marion)                   | Topical q24-72h <sup><a href="#">188</a></sup>                                         | All species/broad-spectrum antibacterial for skin (i.e., wounds, burns) or oral cavity; dressing is generally not necessary |
|                                                                 | 10 mg/kg IM q12-                                                                       | Most species/potentially nephrotoxic;                                                                                       |

|                                         |                                                                |                                                                                   |
|-----------------------------------------|----------------------------------------------------------------|-----------------------------------------------------------------------------------|
| Streptomycin                            | 24h <sup>83</sup>                                              | maintain hydration; avoid in cases of dehydration or renal or hepatic dysfunction |
| Sulfadiazine                            | 25 mg/kg PO<br>q24h <sup>291</sup>                             | Most species/maintain hydration                                                   |
| Sulfadimethoxine                        | 90 mg/kg IM, then<br>45 mg/kg q24h <sup>83</sup>               | Most species/potentially nephrotoxic;<br>maintain hydration                       |
| Ticarcillin (Ticar, SmithKline-Beecham) | 50-100 mg/kg IM<br>q24h <sup>83</sup>                          | Most species/maintain hydration                                                   |
|                                         | 50-100 mg/kg IM,<br>IV q24-48h <sup>195</sup>                  | Loggerhead sea turtles/PD                                                         |
| Tobramycin                              | —                                                              | Potentially nephrotoxic; maintain hydration;<br>potentiated by $\beta$ -lactams   |
|                                         | 2.5 mg/kg IM q24-<br>72h <sup>64,92</sup>                      | Most species                                                                      |
|                                         | 10 mg/kg IM q24-<br>48h <sup>64</sup>                          | Chelonians/can be given q48h in tortoises;<br>fluid therapy recommended           |
| Trimethoprim/sulfadiazine               | —                                                              | Maintain hydration; parenteral form must be<br>compounded                         |
|                                         | 15-25 mg/kg PO<br>q24h <sup>291</sup>                          | Most species                                                                      |
|                                         | 20-30 mg/kg IM<br>q24-48h <sup>160</sup>                       | Most species                                                                      |
|                                         | 30 mg/kg IM q24h<br>× 2 days, then<br>q48h <sup>64,83,86</sup> | Most species/can administer PO, SC                                                |
| Trimethoprim/sulfamethoxazole           | 10-30 mg/kg PO<br>q24h <sup>83</sup>                           | Most species/maintain hydration                                                   |
| Tylosin                                 | 5 mg/kg IM q24h ×<br>10-60 days <sup>64,92</sup>               | Most species/mycoplasmosis                                                        |

<sup>a</sup> Because reptiles are ectothermic, pharmacokinetics of drugs are influenced by ambient temperature. Antimicrobial therapy should be conducted at the upper end of the patient’s preferred (selected) optimum temperature zone.

<sup>b</sup> See [Table A-4](#) for antimicrobial combination therapies, some of which are commonly used in reptiles.

TABLE 4-2 Antiviral Agents Used in Reptiles.

| Agent | Dosage | Species/Comments |
|-------|--------|------------------|
|-------|--------|------------------|

|                        |                                                                            |                                                                                                          |
|------------------------|----------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------|
| Acyclovir              | ≥80 mg/kg PO q24h <sup><a href="#">88</a></sup>                            | Tortoises/PD; herpesvirus; poor oral absorption                                                          |
|                        | 80 mg/kg PO q8h or 240 mg/kg/day PO <sup><a href="#">207</a></sup>         | Tortoises/herpesvirus; uncertain efficacy; unlikely to eliminate infection; combine with supportive care |
|                        | Topical (5% ointment) q12h <sup><a href="#">83</a></sup>                   | All species/antiviral (i.e., herpesvirus-associated dermatitis)                                          |
| Chlorhexidine solution | 0.5% dilution, topical on oral lesions q24h <sup><a href="#">154</a></sup> | Tortoises/herpesvirus                                                                                    |

TABLE 4-3 Antifungal Agents Used in Reptiles.

| Agent                                                                                              | Dosage                                                                              | Species/Comments                                                                      |
|----------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------|
| Amphotericin B                                                                                     | 0.5 mg/kg IV q48-72h <sup><a href="#">84</a></sup>                                  | Most species/nephrotoxic; can use in combination with ketoconazole; administer slowly |
|                                                                                                    | 0.5-1 mg/kg IV, ICe q24-72h × 14-28 days <sup><a href="#">64</a></sup>              | Most species/aspergillosis                                                            |
|                                                                                                    | 1 mg/kg IT q24h × 14-28 days <sup><a href="#">142</a></sup>                         | Most species/respiratory infection; dilute with water or saline                       |
|                                                                                                    | 0.1 mg/kg intrapulmonary q24h × 28 days <sup><a href="#">118</a></sup>              | Greek tortoises/pneumonia                                                             |
|                                                                                                    | 1 mg/kg q24h ICe × 2-4 wk <sup><a href="#">175</a></sup>                            | Crocodilians                                                                          |
|                                                                                                    | 5 mg/150 mL saline × 1 hr nebulization q12h × 7 days <sup><a href="#">136</a></sup> | Most species/pneumonia                                                                |
| Chlorhexidine (Nolvasan 2%, Fort Dodge)                                                            | 20 mL/gal water bath <sup><a href="#">309</a></sup>                                 | Lizards/dermatophytosis                                                               |
| Clotrimazole (Veltrim, Haver-Lockhart; Otomax, with gentamicin and betamethasone, Schering-Plough) | Topical <sup><a href="#">263</a></sup>                                              | Most species/dermatitis; may bathe q12h with dilute organic iodine prior to use       |
| F10 super concentrate disinfectant (Health and Hygiene, Roodeport, South Africa)                   | 1:250 nasal flush, 0.1 mL each nare q24h <sup><a href="#">43</a></sup>              | Terrestrial chelonians                                                                |



|              |                                                                                             |                                                                                                                                                                                            |
|--------------|---------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Fluconazole  | 5 mg/kg PO<br>q24h <sup><a href="#">309</a></sup>                                           | Lizards/dermatophytosis                                                                                                                                                                    |
|              | 21 mg/kg SC<br>once, then 10<br>mg/kg SC 5<br>days later <sup><a href="#">107.194</a></sup> | Loggerhead sea turtles/PD                                                                                                                                                                  |
| Griseofulvin | 20-40 mg/kg PO<br>q72h × 5<br>treatments <sup><a href="#">263</a></sup>                     | Most species/dermatitis; limited success                                                                                                                                                   |
|              | 15 mg/kg PO<br>q72h <sup><a href="#">145-147</a></sup>                                      | Most species                                                                                                                                                                               |
| Itraconazole | 5 mg/kg PO<br>q24h <sup><a href="#">199</a></sup>                                           | Most species/some hepatotoxicity noted when used<br>for <i>Chrysosporium</i> anamorph of <i>Nannizziopsis<br/>vriesii</i>                                                                  |
|              | 10 mg/kg PO<br>q24h <sup><a href="#">219</a></sup>                                          | Snakes                                                                                                                                                                                     |
|              | 5 mg/kg PO<br>q24h <sup><a href="#">113</a></sup>                                           | Panther chameleons                                                                                                                                                                         |
|              | 10 mg/kg PO<br>q48h × 60<br>days <sup><a href="#">22</a></sup>                              | Chameleons (Parson's)/osteomyelitis                                                                                                                                                        |
|              | 23.5 mg/kg PO<br>q24h <sup><a href="#">90</a></sup>                                         | Lizards/PD (spiny lizards); following a 3-day<br>treatment, a therapeutic plasma concen-tration<br>persists for 6 days beyond peak concentration;<br>treatment interval was not determined |
|              | 5 mg/kg PO<br>q24h or 15<br>mg/kg PO<br>q72h <sup><a href="#">196</a></sup>                 | Kemp's Ridley sea turtles                                                                                                                                                                  |
| Ketoconazole | —                                                                                           | May use antibiotics concomitantly to prevent<br>bacterial overgrowth; may use concurrently with<br>thiabendazole                                                                           |
|              | 15-30 mg/kg PO<br>q24h × 14-28<br>days <sup><a href="#">92</a></sup>                        | Most species                                                                                                                                                                               |
|              | 25 mg/kg PO<br>q24h × 21<br>days <sup><a href="#">137</a></sup>                             | Snakes, turtles                                                                                                                                                                            |
|              | 15 mg/kg PO<br>q72h <sup><a href="#">145-147</a></sup>                                      | Most species                                                                                                                                                                               |
|              | 15-30 mg/kg PO<br>q24h × 14-28                                                              | Chelonians/PD (gopher tortoises); systemic                                                                                                                                                 |



|                                                 |                                                           |                                                                                                                     |
|-------------------------------------------------|-----------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------|
|                                                 | days <sup>204,244</sup>                                   | infection                                                                                                           |
|                                                 | 50 mg/kg PO<br>q24h × 14-28<br>days <sup>291</sup>        | Crocodilians                                                                                                        |
| Malachite green                                 | 0.15 mg/L water<br>× 1 hr bath × 14<br>days <sup>64</sup> | Dermatitis                                                                                                          |
| Miconazole (Monistat-Derm, Ortho)               | Topical <sup>263</sup>                                    | Most species/dermatitis; may bathe q12h with dilute organic iodine before use                                       |
| Nystatin                                        | 100,000 U/kg<br>PO q24h × 10<br>days <sup>136</sup>       | Most species/enteric yeast infections; limited success                                                              |
| Thiabendazole                                   | 50 mg/kg PO<br>q24h × 14<br>days <sup>138</sup>           | Chelonians/pneumonia; dermatitis; may use concurrently with ketoconazole                                            |
| Tolnaftate 1% cream (Tinactin, Schering-Plough) | Topical q12h<br>prn <sup>3</sup>                          | Most species/dermatitis; may bathe q12h with dilute organic iodine before use                                       |
| Voriconazole                                    | 10 mg/kg PO <sup>302</sup>                                | Bearded dragons/no hepatotoxicity noted when used for <i>Chrysosporium</i> anamorph of <i>Nannizziopsis vriesii</i> |
|                                                 | 5 mg/kg SC <sup>132</sup>                                 | Red-eared sliders/exceeded MIC only until 4 hr post-injection; 26°C (78°F)                                          |

TABLE 4-4 Antiparasitic Agents Used in Reptiles.

| Agent                                                | Dosage                                                                                   | Species/Comments                                                                                                                                                                                                                          |
|------------------------------------------------------|------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Albendazole                                          | 50 mg/kg PO <sup>291</sup>                                                               | Most species/ascarids                                                                                                                                                                                                                     |
| Carbaryl powder (5%)                                 | Lightly dust animal and environment; rinse after 1 hr; repeat in 7 days <sup>75,86</sup> | Lizards; snakes/mites                                                                                                                                                                                                                     |
| Chloroquine                                          | 125 mg/kg PO<br>q48h × 3<br>treatments <sup>291</sup>                                    | Tortoises/hemoprotozoa                                                                                                                                                                                                                    |
| Dichlorvos (Vapona No-Pest Strip; United Industries) | 6 mm strip/10 ft <sup>3</sup><br>in cage × 3 hr q48h<br>× 2-4 wk <sup>83,311</sup>       | Most species/mites; toxicity occurs; <sup>86</sup> prevent contact with animals (e.g., place strip above cage or inside perforated container); avoid in cases of renal or hepatic dysfunction; remove water container; use is discouraged |
| Dimetridazole (Emtryl, Rhône-                        | —                                                                                        | Not available in the United States                                                                                                                                                                                                        |
|                                                      | 100 mg/kg PO                                                                             |                                                                                                                                                                                                                                           |

|                                                               |                                                                                     |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
|---------------------------------------------------------------|-------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Poulenc)                                                      | once, repeat in 2 wk <sup><a href="#">307</a></sup>                                 | Most species/amoebae                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
|                                                               | 40 mg/kg PO q24h × 5-8 days <sup><a href="#">136,210</a></sup>                      | Snakes (except milk and indigo)/amoebae; flagellates                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
|                                                               | 40 mg/kg PO, repeat in 14 days <sup><a href="#">307</a></sup>                       | Milk and indigo snakes/amoebae; flagellates                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
| Emodepside (1.98%) + praziquantel (7.94%) (Profender, Bayer)  | 1.12 mL/kg <sup><a href="#">213,267</a></sup>                                       | Many species/PD; nematodes; cestodes; aquatic turtles must be kept dry for 48 hr after application; appears to be safe, but needs more safety and efficacy data                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
| Fenbendazole                                                  | —                                                                                   | Drug of choice for nematodes; may have an antiprotozoan effect; may cause leukopenia, avoid in septicemic patients <sup><a href="#">230</a></sup>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
|                                                               | 25-100 mg/kg PO q14d for up to 4 treatments <sup><a href="#">31,136,158</a></sup>   | All species/nematodes                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
|                                                               | 50 mg/kg PO q24h × 3-5 days <sup><a href="#">86,161,162</a></sup>                   | All species/nematodes (× 3 days); flagellates and giardia in chameleons (× 5 days)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
|                                                               | 100 mg/kg once <sup><a href="#">94</a></sup>                                        | Tortoises/nematodes; shedding of ova continues for 30 days                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
| Fipronil (0.29%; Frontline Spray, Merial)                     | Spray or wipe on then wash off in 5 min q7-10d prn <sup><a href="#">75,86</a></sup> | Most species/mites, ticks; beware of reactions to alcohol carrier; needs safety evaluation <sup><a href="#">38</a></sup>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
| Imidocloprid and moxidectin (Advantage multi/Advocate, Bayer) | 0.2 mg/kg topical q14d × 3 treatments <sup><a href="#">103</a></sup>                | Lizards/eliminated hookworms and pinworms; needs safety and pharmacokinetic evaluation                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
| Ivermectin                                                    | —                                                                                   | Do not use in chelonians, <sup><a href="#">298</a></sup> crocodilians, indigo snakes, or skinks <sup><a href="#">31,162,291</a></sup>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
|                                                               | 0.2 mg/kg PO, SC, IM, repeat in 14 days <sup><a href="#">10,76,307</a></sup>        | Snakes (except indigos), lizards (except skinks) <sup><a href="#">31</a></sup> /nematodes (including lungworms), <sup><a href="#">180</a></sup> mites; can dilute with propylene glycol for oral use; colored animals may have skin discoloration at injection site; rare adverse effects reported in chameleons, possibly associated with breakdown of parasites; <sup><a href="#">10</a></sup> do not use within 10 days of diazepam or tiletamine/zolazepam; rare death and occasional nervous system signs, lethargy, or inappetence have been reported; <sup><a href="#">162</a></sup> used for pentastomids in monitor lizards (with dexamethasone 0.2 mg/kg q2d) <sup><a href="#">76</a></sup> |

|                                               |                                                                  |                                                                                                                                                                                                                                                                                                                                                                                                        |
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|                                               | 5-10 mg/L water topical spray q3-5d up to 28 days <sup>162</sup> | Snakes (except indigos), lizards (except skinks)/mites; less effective than fipronil; spray on skin and in newly cleaned cage, then allow to dry before replacing water dish                                                                                                                                                                                                                           |
| Levamisole<br>(Levasole 13.65%, Mallinckrodt) | 5-10 mg/kg SC, ICe, repeat in 14 days <sup>160</sup>             | Most species/5 mg/kg in chelonians; <sup>243</sup> 10 mg/kg in lizards, <sup>10</sup> snakes; <sup>136</sup> nematodes (including lungworms); very narrow range of safety; main advantage is that it can be administered parenterally; avoid concurrent use with chloramphenicol; avoid use in debilitated animals; low dose may stimulate depressed immune system; can be used IM, but less effective |
| Mebendazole                                   | 20-25 mg/kg PO, repeat in 14 days prn <sup>136,291</sup>         | Most species/strongyles, ascarids                                                                                                                                                                                                                                                                                                                                                                      |
| Metronidazole                                 | —                                                                | Protozoan (i.e., flagellates, amoebae) overgrowth; may stimulate appetite; may cause severe neurologic signs at doses >200 mg/kg; <sup>220</sup> death occurred in indigo and mountain king snakes at 100 mg/kg; <sup>136</sup> for small patients, injectable form can be administered PO; oral liquid is not available in the United States, but can be compounded                                   |
|                                               | 40-100 mg/kg PO, repeat in 10-14 days <sup>83</sup>              | Most species/flagellate overgrowth                                                                                                                                                                                                                                                                                                                                                                     |
|                                               | 20 mg/kg PO q48h <sup>25</sup>                                   | Corn snakes/PD; 28°C (82°F); protozoa                                                                                                                                                                                                                                                                                                                                                                  |
|                                               | 40 mg/kg PO, repeat in 14 days <sup>86,136</sup>                 | Uracoan rattler, milk, tricolor king, and indigo snakes/flagellates                                                                                                                                                                                                                                                                                                                                    |
|                                               | 40-60 mg/kg PO q7d × 2-3 doses <sup>287</sup>                    | Chameleons/flagellates; amoebae                                                                                                                                                                                                                                                                                                                                                                        |
|                                               | 40-200 mg/kg PO, repeat in 14 days <sup>216</sup>                | Geckos/ocular lesions (40 mg/kg) and subcutaneous lesions (200 mg/kg) caused by <i>Trichomonas</i>                                                                                                                                                                                                                                                                                                     |
|                                               | 50 mg/kg PO q24h × 2-5 days <sup>161</sup>                       | Chameleons/when accompanied by increased gastrointestinal symptoms                                                                                                                                                                                                                                                                                                                                     |
|                                               | 20 mg/kg ICe q48h <sup>131</sup>                                 | Red-eared sliders/PD; ICe administration not recommended; needs further safety evaluation                                                                                                                                                                                                                                                                                                              |
|                                               | 25 mg/kg PO q24h × 5 days or 50 mg/kg PO q14d prn <sup>96</sup>  | Chelonians (tortoises)/amoebae; use 25 mg/kg dosage for clinically ill cases                                                                                                                                                                                                                                                                                                                           |
| Milbemycin                                    | 0.25-0.5 mg/kg SC prn <sup>24</sup>                              | Chelonians/nematodes; parenteral form is not commercially available in the United States; fenbendazole                                                                                                                                                                                                                                                                                                 |

|                                           |                                                                                                                                                             |                                                                                                                                                                            |
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|                                           |                                                                                                                                                             | preferred                                                                                                                                                                  |
| Nitrofurazone                             | 25.5 mg/kg PO <sup><a href="#">306</a></sup>                                                                                                                | Most species/coccidia; seldom used                                                                                                                                         |
| Olive oil                                 | Coat skin q7d <sup><a href="#">10,75</a></sup>                                                                                                              | Most species, especially small, delicate lizards/mites; wash animal with mild soap (and rinse well) the next day; messy to use; environment must be treated with acaricide |
| Oxfendazole<br>(Benzelmin, Fort Dodge)    | 66 mg/kg PO, repeat in 14-28 days prn <sup><a href="#">100</a></sup>                                                                                        | Most species/nematodes                                                                                                                                                     |
| Paromomycin<br>(Humatin, Parke Davis)     | 35-100 mg/kg PO q24h × ≤28 days <sup><a href="#">83,136,307</a></sup>                                                                                       | Most species/amoebae                                                                                                                                                       |
|                                           | 100 mg/kg PO q24h × 7 days, then 2 ×/wk × 3 mo <sup><a href="#">51</a></sup>                                                                                | Snakes/cryptosporidia; reduced clinical signs and oocyte shedding; does not eliminate the organism                                                                         |
|                                           | 300-360 mg/kg PO q48h × 14 days <sup><a href="#">245</a></sup>                                                                                              | Lizards (gila monsters)/cryptosporidia                                                                                                                                     |
|                                           | 300-800 mg/kg PO q24h prn <sup><a href="#">47</a></sup>                                                                                                     | Geckos/cryptosporidia; reduced clinical signs; does not eliminate the organism                                                                                             |
| Permethrin (Provent-a-Mite, Pro Products) | Environmental treatment, 1 sec of spray/ft <sup><a href="#">2</a></sup> ; wait until dry before returning animal to enclosure <sup><a href="#">75</a></sup> | Lizards, snakes/mites; ticks; FDA approved; safe and effective; wash immediately if accidentally applied to skin                                                           |
|                                           | Topical <sup><a href="#">75</a></sup>                                                                                                                       | Tortoises/ticks                                                                                                                                                            |
| Piperazine                                | 40-60 mg/kg PO, repeat in 14 days <sup><a href="#">291</a></sup>                                                                                            | Most species/ascarids                                                                                                                                                      |
|                                           | 100-200 mg/kg PO <sup><a href="#">129</a></sup>                                                                                                             | Crocodylians                                                                                                                                                               |
| Ponazuril                                 | 30 mg/kg PO q48h × 2 treatments <sup><a href="#">26,221</a></sup>                                                                                           | Bearded dragons/coccidiosis                                                                                                                                                |
| Praziquantel (see also Emodepside)        | 8 mg/kg PO, SC, IM, repeat in 14 days <sup><a href="#">10,144,291</a></sup>                                                                                 | Most species/cestodes, trematodes; higher dosages have been administered <sup><a href="#">86</a></sup>                                                                     |
|                                           | 5-10 mg/kg PO q14d <sup><a href="#">161</a></sup>                                                                                                           | Chameleons/flukes may best be left untreated if not causing a problem                                                                                                      |
|                                           | 25-50 mg/kg PO q3h × 3 treatments <sup><a href="#">1,139</a></sup>                                                                                          | Sea turtles (green, loggerhead)/PD; spirorchidiasis                                                                                                                        |

|                                                            |                                                                          |                                                                                                                                                                                                                                                                                  |
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| Pyrantel pamoate                                           | 5 mg/kg PO, repeat in 14 days <sup>162</sup>                             | Most species/nematodes                                                                                                                                                                                                                                                           |
|                                                            | 25 mg/kg PO q24h × 3 days; repeat in 3 wk <sup>86,210</sup>              | Most species/ascarids, hookworms, pinworms                                                                                                                                                                                                                                       |
| Pyrethrin spray (0.09%)                                    | Topical q7d × 2-3 treatments <sup>75</sup>                               | Most species/use water-based sprays labeled for kittens and puppies; apply with cloth; can also spray cage, wash out after 30 min; use sparingly and with caution; pyrethroids are safer (see permethrin, resmethrin)                                                            |
| Quinacrine (Atabrine, Winthrop)                            | 19-100 mg/kg PO q48h × 14-21 days <sup>306</sup>                         | Most species/some hematozoa                                                                                                                                                                                                                                                      |
| Quinine sulfate                                            | 75 mg/kg PO q48h × 14-28 days <sup>306</sup>                             | Most species/some hematozoa; toxic at >100 mg/kg q24h; ineffective against exoerythrocytic forms                                                                                                                                                                                 |
| Resmethrin spray or shampoo (Durakyl, DVM Pharmaceuticals) | Topical, repeat q≥10d prn <sup>75</sup>                                  | Most species/mites; a pyrethroid; safer than pyrethrins; use with care; spray (0.35%) or shampoo entire animal, then rinse off immediately in running, tepid water; protect eyes (other than snakes) with 1 drop of mineral oil; lightly spray environment, wipe off in 5-10 min |
| Spiramycin (Spirasol, May and Baker)                       | 160 mg/kg PO q24h × 10 days, then 2 ×/wk for 3 mo <sup>51</sup>          | Snakes/cryptosporidia; may reduce clinical signs and oocyte shedding; does not eliminate the organism                                                                                                                                                                            |
| Sulfadiazine, sulfamerazine                                | —                                                                        | Most species/coccidia; avoid sulfa drugs in cases of dehydration, urinary calculi, or renal dysfunction <sup>220</sup>                                                                                                                                                           |
|                                                            | 75 mg/kg PO, then 45 mg/kg q24h × 5 days <sup>83,161,306</sup>           | Most species/coccidia                                                                                                                                                                                                                                                            |
|                                                            | 25 mg/kg PO q24h × 21 days <sup>10,138,306</sup>                         | Snakes, lizards/coccidia                                                                                                                                                                                                                                                         |
| Sulfadimethoxine                                           | 50 mg/kg PO q24h × 3-5 days, then q48h prn <sup>162</sup>                | Most species/coccidia; ensure adequate hydration and renal function                                                                                                                                                                                                              |
|                                                            | 90 mg/kg PO, IM, IV, then 45 mg/kg q24h × 5-7 days <sup>83,136,306</sup> | Most species/coccidia                                                                                                                                                                                                                                                            |
| Sulfadimidine (33% solution)                               | 0.3-0.6 mL/kg PO q24h × 10 days <sup>306</sup>                           | Most species/coccidia; alternatively, 0.3-0.6 mL/kg, then 0.15-0.3 mL/kg q24h × 10 days                                                                                                                                                                                          |
|                                                            | 1 oz/gal drinking water × 10 days <sup>306</sup>                         | Most species/coccidia                                                                                                                                                                                                                                                            |
|                                                            |                                                                          |                                                                                                                                                                                                                                                                                  |

|                                   |                                                                                                     |                                                                                                                                                                            |
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| Sulfamethazine                    | 25 mg/kg PO, IM<br>q24h × 21 days <sup>306</sup>                                                    | Most species/coccidia                                                                                                                                                      |
|                                   | 50 mg/kg PO q24h<br>× 3 days, off 3<br>days, on 3 days <sup>100</sup>                               | Most species/coccidia                                                                                                                                                      |
|                                   | 75 mg/kg PO, IM,<br>IV, then 40 mg/kg<br>q24h × 5-7<br>days <sup>92,136</sup>                       | Most species/coccidia; ensure adequate hydration and renal function                                                                                                        |
| Sulfamethoxydiazine               | 80 mg/kg SC, IM,<br>then 40 mg/kg<br>q24h × 4 days <sup>306</sup>                                   | Most species/coccidia; ensure adequate hydration and renal function                                                                                                        |
| Sulfaquinoxaline                  | 75 mg/kg PO, then<br>40 mg/kg q24h ×<br>5-7 days <sup>136</sup>                                     | Most species/coccidia                                                                                                                                                      |
| Thiabendazole                     | 50-100 mg/kg PO,<br>repeat in 14<br>days <sup>84,136</sup>                                          | Most species/nematodes; fenbendazole preferred                                                                                                                             |
| Toltrazuril 5%<br>(Baycox, Bayer) | 5-15 mg/kg q24h ×<br>3 days <sup>68</sup>                                                           | Bearded dragons/coccidiosis                                                                                                                                                |
|                                   | 15 mg/kg q48h ×<br>10 days;<br>discontinue for 2<br>wk; repeat q48h ×<br>10 days prn <sup>247</sup> | Tortoises/intranuclear coccidiosis; needs safety, efficacy, and pharmacokinetic study                                                                                      |
| Trimethoprim/sulfa                | —                                                                                                   | Most species/coccidia; avoid potentiated sulfa drugs in cases of dehydration or renal dysfunction <sup>220</sup>                                                           |
|                                   | 30 mg/kg PO q24h<br>× 2 days, then q48h<br>× 21 days <sup>10,306</sup>                              | Most species/coccidia                                                                                                                                                      |
|                                   | 30 mg/kg IM q24h<br>× 2 days, then 15<br>mg/kg IM q48h ×<br>10-28 days <sup>306</sup>               | Most species/coccidia                                                                                                                                                      |
|                                   | 30 mg/kg PO q24h<br>× 14 days, then 1-3<br>×/wk × 3-6 mo <sup>51</sup>                              | Most species/cryptosporidia; can reduce shedding but does not clear infection                                                                                              |
| Water                             | Bath × 30<br>min <sup>75,185</sup>                                                                  | Snakes, lizards/mites; use lukewarm (29°C [85°F]) water; monitor to avoid drowning; not 100% effective; does not kill mites on head; must treat environment with acaricide |

TABLE 4-5 Chemical Restraint/Anesthetic Agents Used in Reptiles.



| Agent                              | Dosage                                                                                                                                                   | Species/Comments                                                                                                                                                                                                                                                                                   |
|------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Acepromazine                       | 0.05-0.25 mg/kg<br>IM <sup><a href="#">143</a></sup>                                                                                                     | Most species/can be used as a preanesthetic with ketamine                                                                                                                                                                                                                                          |
|                                    | 0.1-0.5 mg/kg<br>IM <sup><a href="#">217,242</a></sup>                                                                                                   | Most species/preanesthetic; reduce by 50% if used with barbiturates                                                                                                                                                                                                                                |
| Alphaxalone<br>(Alfaxan, Jurox)    | —                                                                                                                                                        | Not available in the United States                                                                                                                                                                                                                                                                 |
|                                    | 6-9 mg/kg IV, or<br>9-15 mg/kg<br>IM <sup><a href="#">173</a></sup>                                                                                      | Most species/good muscle relaxation; variable results; drug requires more evaluation; may have violent recovery; <sup><a href="#">12</a></sup><br>don't use within 10 days of DMSO treatment                                                                                                       |
|                                    | 6-15 mg/kg IM,<br>IV <sup><a href="#">273</a></sup>                                                                                                      | Most species                                                                                                                                                                                                                                                                                       |
|                                    | 9 mg/kg IV <sup><a href="#">266</a></sup>                                                                                                                | Snakes, lizards/induction; not effective for blotched blue-tongued skinks                                                                                                                                                                                                                          |
|                                    | 15 mg/kg IM <sup><a href="#">217</a></sup>                                                                                                               | Lizards, chelonians/induction, 35-40 min; duration, 15-35 min; good muscle relaxation; variable results                                                                                                                                                                                            |
|                                    | 24 mg/kg ICe <sup><a href="#">104</a></sup>                                                                                                              | Chelonians (red-eared sliders)/surgical anesthesia with good relaxation                                                                                                                                                                                                                            |
| Atipamezole<br>(Antisedan, Pfizer) | Give same volume SC, IV, IP as medetomidine or dexmedetomidine (5 × medetomidine or 10 × dexmedetomidine dose in mg) <sup><a href="#">a,78,278</a></sup> | Most species/medetomidine and dexmedetomidine reversal; causes severe hypotension in gopher tortoises when given IV <sup><a href="#">56</a></sup>                                                                                                                                                  |
|                                    | 0.2-0.5 mg/kg<br>IM <sup><a href="#">77</a></sup>                                                                                                        | Chelonians/shell repair 5-10 min before finished                                                                                                                                                                                                                                                   |
|                                    | 0.5-0.75 mg/kg<br>IM <sup><a href="#">256</a></sup>                                                                                                      | Chelonians                                                                                                                                                                                                                                                                                         |
| Atropine                           | 0.01-0.04 mg/kg<br>SC, IM, <sup><a href="#">27</a></sup> IV, <sup><a href="#">84</a></sup><br>ICe <sup><a href="#">270</a></sup>                         | Most species/preanesthetic; bradycardia; rarely indicated; generally use only in profound or prolonged bradycardia; <sup><a href="#">270</a></sup> may help prevent intracardiac shunting; <sup><a href="#">145</a></sup> ineffective at this dose in green iguanas <sup><a href="#">241</a></sup> |
|                                    | 0.5 mg/kg IM,<br>IV, IT, IO <sup><a href="#">220</a></sup>                                                                                               | Most species/bradycardia, decrease secretions, CPR                                                                                                                                                                                                                                                 |
| Butorphanol                        | —                                                                                                                                                        | Butorphanol combinations follow; see ketamine for combinations                                                                                                                                                                                                                                     |
|                                    |                                                                                                                                                          |                                                                                                                                                                                                                                                                                                    |

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|                                                                      | 0.4-1 mg/kg SC,<br>IM <sup><a href="#">270</a></sup>                       | Most species/analgesia; sedation; preanesthetic                                                                                                                   |
|                                                                      | 0.5-2 mg/kg IM<br>or 0.2-0.5 mg/kg<br>IV, IO <sup><a href="#">18</a></sup> | Most species/preanesthetic                                                                                                                                        |
|                                                                      | 1-2 mg/kg IM <sup><a href="#">18</a></sup>                                 | Snakes/analgesia                                                                                                                                                  |
|                                                                      | 0.05 mg/kg IM<br>q24h × 2-3<br>days <sup><a href="#">184</a></sup>         | Lizards (iguanas)/analgesia                                                                                                                                       |
|                                                                      | 1-1.5 mg/kg SC,<br>IM <sup><a href="#">270</a></sup>                       | Lizards/administer 30 min prior to isoflurane for smooth,<br>shorter induction                                                                                    |
|                                                                      | 0.2 mg/kg<br>IM <sup><a href="#">109,256</a></sup>                         | Chelonians/tranquilizer                                                                                                                                           |
| Butorphanol<br>(B)/medetomidine<br>(M)                               | (B) 0.4 mg/kg +<br>(M) 0.08 mg/kg<br>IM <sup><a href="#">93</a></sup>      | Green tree monitor/sedation                                                                                                                                       |
| Butorphanol<br>(B)/midazolam (M)                                     | (B) 0.4 mg/kg +<br>(M) 2 mg/kg<br>IM <sup><a href="#">16</a></sup>         | Most species/preanesthetic; administer 20 min before<br>induction                                                                                                 |
| Chlorpromazine                                                       | 0.1-0.5 mg/kg<br>IM <sup><a href="#">84</a></sup>                          | Most species/preanesthetic; not commonly used                                                                                                                     |
|                                                                      | 10 mg/kg IM <sup><a href="#">12</a></sup>                                  | Chelonians/preanesthetic                                                                                                                                          |
| Dexmedetomidine <sup><a href="#">a</a></sup><br>(Dexdomitor; Pfizer) | —                                                                          | $\alpha_2$ agonist that has replaced medetomidine <sup><a href="#">a</a></sup>                                                                                    |
| Diazepam                                                             | —                                                                          | See ketamine for combinations; muscle relaxation; give 20<br>min prior to anesthesia; potentially reversible with<br>flumazenil; drug interaction with ivermectin |
|                                                                      | 0.5 mg/kg IM,<br>IV <sup><a href="#">220</a></sup>                         | All species/seizures                                                                                                                                              |
|                                                                      | 2.5 mg/kg IM,<br>IV <sup><a href="#">264</a></sup>                         | Most species/seizures                                                                                                                                             |
|                                                                      | 0.2-0.8 mg/kg<br>IM <sup><a href="#">270</a></sup>                         | Snakes/use in conjunction with ketamine for anesthesia<br>with muscle relaxation                                                                                  |
|                                                                      | 0.2-2 mg/kg IM,<br>IV <sup><a href="#">273</a></sup>                       | Snakes, lizards                                                                                                                                                   |
|                                                                      | 2.5 mg/kg PO <sup><a href="#">270</a></sup>                                | Iguanas/reduce anxiety, which often leads to aggression                                                                                                           |
|                                                                      | 0.2-1 mg/kg<br>IM <sup><a href="#">270,273</a></sup>                       | Chelonians/use in conjunction with ketamine for anesthesia<br>with muscle relaxation                                                                              |
| Disoprofol                                                           | 5-15 mg/kg IV to<br>effect <sup><a href="#">30</a></sup>                   | All species/anesthesia; similar characteristics to propofol;<br>not available in the United States                                                                |



|                                            |                                                                                                                                 |                                                                                                                                                                                                                                                                                                                                                                                       |
|--------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Doxapram                                   | 5 mg/kg IM, IV <sup>16</sup><br>q10min prn                                                                                      | Most species/respiratory stimulant; reduces recovery time; reported to partially “reverse” effects of dissociatives <sup>174</sup>                                                                                                                                                                                                                                                    |
|                                            | 4-12 mg/kg IM, IV <sup>270</sup>                                                                                                | Most species/respiratory stimulant                                                                                                                                                                                                                                                                                                                                                    |
|                                            | 20 mg/kg IM, IV, IO <sup>220</sup>                                                                                              | Most species/respiratory stimulant                                                                                                                                                                                                                                                                                                                                                    |
| Epinephrine (1:1000)                       | 0.5-1 mg/kg IV, IO, IT <sup>220</sup>                                                                                           | Most species/CPR, cardiac arrest                                                                                                                                                                                                                                                                                                                                                      |
| Etorphine (M-99, Wildlife Pharmaceuticals) | 0.3-0.5 mg/kg IM <sup>217</sup><br>0.3-2.75 mg/kg IM <sup>173</sup>                                                             | Crocodylians, chelonians/very potent narcotic; crocodylians: induction, 5-30 min; duration, 30-180 min; chelonians: induction, 10-20 min; duration, 40-120 min; not very effective in reptiles other than alligators; <sup>242</sup> poor relaxation; adequate for immobilization and minor procedures; requires an antagonist; limited use because of expense and legal restrictions |
| Flumazenil (Romazicon, Hoffman-LaRoche)    | —                                                                                                                               | All species/reversal of benzodiazepines, including diazepam and midazolam; seldom indicated                                                                                                                                                                                                                                                                                           |
|                                            | 1 mg/20 mg of zolazepam <sup>177</sup> IM, IV <sup>256</sup>                                                                    | Crocodylians, chelonians/reversal of zolazepam                                                                                                                                                                                                                                                                                                                                        |
| Gallamine (Flaxedil, American Cyanamid)    | 0.4-1.25 mg/kg IM <sup>13</sup><br>0.6-4 mg/kg IM <sup>178</sup><br>0.7 mg/kg IM <sup>224</sup><br>1.2-2 mg/kg IM <sup>78</sup> | Crocodyles/results in flaccid paralysis, but no analgesia; larger animals require lower dosage; reverse with neostigmine; <sup>178</sup> use in alligators questionable; unsafe in alligators at ≥1 mg/kg, <sup>242</sup> deaths reported in American alligators and false gharials <sup>175</sup>                                                                                    |
|                                            | 0.5-2 mg/kg IM <sup>169</sup>                                                                                                   | Crocodylians                                                                                                                                                                                                                                                                                                                                                                          |
| Glycopyrrolate                             | 0.01 mg/kg SC, <sup>27</sup> IM, IV <sup>16</sup>                                                                               | Most species/preanesthetic; for excess oral or respiratory mucus; rarely indicated; generally use only in profound or prolonged bradycardia; may be preferable to atropine; <sup>84</sup> does not work at this dose in green iguanas <sup>241</sup>                                                                                                                                  |
| Haloperidol                                | 0.5-10 mg/kg IM q7-14d <sup>290</sup>                                                                                           | Boids/aggression management                                                                                                                                                                                                                                                                                                                                                           |
|                                            |                                                                                                                                 |                                                                                                                                                                                                                                                                                                                                                                                       |

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| Hyaluronidase<br>(Wydase, Wyeth) | 25 U/dose SC <sup>177</sup>                                                | Crocodylians/combine with premedication, anesthetic, or reversal drugs to accelerate SC absorption                                                                                                                                                                                                                                                                                                                                                       |
| Isoflurane                       | 3-5%<br>induction, <sup>142</sup><br><br>1-3%<br>maintenance <sup>31</sup> | Most species/inhalation anesthetic of choice in reptiles; induction, 6-20 min; recovery, 30-60 min; not as smooth in reptiles compared to other animals; intubation and intermittent positive pressure ventilation advisable; may preanesthetize with low dose propofol, ketamine, etc.                                                                                                                                                                  |
|                                  | 5% via chamber<br>in 5 L O <sub>2</sub> /min <sup>124</sup>                | Green iguanas/15-35 min loss of righting reflex; mean MAC, 1.62%; pH 7.49                                                                                                                                                                                                                                                                                                                                                                                |
| Ketamine                         | —                                                                          | Ketamine combinations follow; muscle relaxation and analgesia may be marginal; prolonged recovery with higher doses; larger reptiles require lower dose; painful at injection site; safety is questionable in debilitated patients; avoid use in cases with renal dysfunction; snakes may be permanently aggressive after ketamine anesthesia; <sup>12</sup> generally recommend use only as a preanesthetic prior to isoflurane for surgical anesthesia |
|                                  | 10 mg/kg SC, IM<br>q30min <sup>27</sup>                                    | Most species/maintenance of anesthesia; recovery, 3-4 hr                                                                                                                                                                                                                                                                                                                                                                                                 |
|                                  | 20-60 mg/kg IM,<br>or 5-15 mg/kg<br>IV <sup>143</sup>                      | Most species/muscle relaxation improved with midazolam or diazepam                                                                                                                                                                                                                                                                                                                                                                                       |
|                                  | 22-44 mg/kg SC,<br>IM <sup>12,13</sup>                                     | Most species/sedation                                                                                                                                                                                                                                                                                                                                                                                                                                    |
|                                  | 55-88 mg/kg SC,<br>IM <sup>13</sup>                                        | Most species/surgical anesthesia; induction, 10-30 min; recovery, 24-96 hr                                                                                                                                                                                                                                                                                                                                                                               |
|                                  | 10-20 mg/kg<br>IM <sup>219,220</sup>                                       | Snakes, chelonians/sedation                                                                                                                                                                                                                                                                                                                                                                                                                              |
|                                  | 20-60 mg/kg SC,<br>IM <sup>27,149</sup>                                    | Snakes/sedation; induction, 30 min; recovery, 2-48 hr                                                                                                                                                                                                                                                                                                                                                                                                    |
|                                  | 60-80 mg/kg<br>IM <sup>31</sup>                                            | Snakes/light anesthesia; intermittent positive pressure ventilation may be needed at higher doses                                                                                                                                                                                                                                                                                                                                                        |
|                                  | 5-10 mg/kg <sup>220,270</sup>                                              | Lizards, snakes/decreases the incidence of breath-holding during chamber induction                                                                                                                                                                                                                                                                                                                                                                       |
|                                  | 20-30 mg/kg<br>IM <sup>74</sup>                                            | Iguanas/sedation (i.e., facilitates endotracheal intubation); preanesthetic; requires lower dose than other reptiles                                                                                                                                                                                                                                                                                                                                     |
|                                  | 30-50 mg/kg SC,<br>IM <sup>27,149</sup>                                    | Lizards/sedation; variable results                                                                                                                                                                                                                                                                                                                                                                                                                       |
|                                  | 20-60 mg/kg                                                                | Chelonians/sedation; induction, 30 min; recovery, ≥24 hr; potentially dangerous in dehydrated and debilitated                                                                                                                                                                                                                                                                                                                                            |

|                                                            |                                                                                                    |                                                                                                                                                                                                                                    |
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|                                                            | IM <sup><a href="#">127,149,242</a></sup>                                                          | tortoises                                                                                                                                                                                                                          |
|                                                            | 25 mg/kg IM, IV <sup><a href="#">304</a></sup>                                                     | Sea turtles/sedation; used at higher doses (50-70 mg/kg); recovery times may be excessively long and unpredictable; combination of ketamine and acepromazine gives a more rapid induction and recovery                             |
|                                                            | 38-71 mg/kg ICe <sup><a href="#">310</a></sup>                                                     | Green sea turtles/anesthesia; induction, 2-10 min; duration, 2-10 min; recovery, <30 min                                                                                                                                           |
|                                                            | 60-90 mg/kg IM <sup><a href="#">149,217</a></sup>                                                  | Chelonians/light anesthesia; induction, <30 min; recovery, hours to days; requires higher doses than most other reptiles                                                                                                           |
|                                                            | 20-40 mg/kg (sedation) to 40-80 mg/kg (anesthesia) SC, IM, ICe <sup><a href="#">177</a></sup>      | Crocodylians/induction, <30-60 min; recovery, hours to days; in larger animals, 12-15 mg/kg may permit tracheal intubation; <sup><a href="#">270</a></sup> not recommended alone in Nile crocodiles <sup><a href="#">169</a></sup> |
|                                                            | 20-100 mg/kg IM <sup><a href="#">175</a></sup>                                                     | Crocodylians/lower dose for sedation, higher for anesthesia (requires intermittent positive pressure ventilation for hours)                                                                                                        |
| Ketamine (K)/acepromazine (A)                              | —                                                                                                  | See (K) and (A) for dosage recommendations                                                                                                                                                                                         |
| Ketamine (K)/butorphanol (B)                               | See (K) dosages + (B) ≤1.5 mg/kg IM <sup><a href="#">270</a></sup>                                 | Snakes/anesthesia with improved muscle relaxation                                                                                                                                                                                  |
|                                                            | (K) 10-30 mg/kg + (B) 0.5-1.5 mg/kg IM <sup><a href="#">270</a></sup>                              | Chelonians/minor surgical procedures (i.e., shell repair)                                                                                                                                                                          |
| Ketamine (K)/diazepam (D)                                  | See (K) dosages + (D) 0.2-0.8 mg/kg IM <sup><a href="#">270</a></sup>                              | Snakes/anesthesia with improved muscle relaxation                                                                                                                                                                                  |
|                                                            | (K) 60-80 mg/kg <sup><a href="#">217</a></sup> + (D) 0.2-1 mg/kg IM <sup><a href="#">270</a></sup> | Chelonians/anesthesia; muscle relaxation                                                                                                                                                                                           |
| Ketamine (K)/medetomidine (M) <sup><a href="#">a</a></sup> | —                                                                                                  | Medetomidine is no longer commercially available, but can be compounded; <sup><a href="#">a</a></sup> reverse medetomidine with atipamezole                                                                                        |
|                                                            | (K) 10 mg/kg + (M) 0.1-0.3 mg/kg IM <sup><a href="#">65</a></sup>                                  | Most species                                                                                                                                                                                                                       |
|                                                            | (K) 5-10 mg/kg IM + (M) 0.1-0.15 mg/kg IM,                                                         | Lizards (iguanas)                                                                                                                                                                                                                  |

|                               |                                                                                   |                                                                                   |
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|                               | IV <sup>111</sup><br>(K) 3-8 mg/kg +<br>(M) 0.025-0.08<br>mg/kg IV <sup>179</sup> | Giant tortoises (Aldabra)                                                         |
|                               | (K) 4 mg/kg +<br>(M) 0.04 mg/kg<br>IM <sup>115</sup>                              | Green sea turtles                                                                 |
|                               | (K) 4-10 mg/kg +<br>(M) 0.04-0.14<br>mg/kg IM <sup>77</sup>                       | Chelonians/sedation and muscle relaxation for shell repair                        |
|                               | (K) 5 mg/kg +<br>(M) 0.05 mg/kg<br>IV <sup>42</sup>                               | Loggerhead sea turtles/induction of anesthesia for<br>intubation                  |
|                               | (K) 5 mg/kg +<br>(M) 0.05 mg/kg<br>IM <sup>236</sup>                              | Tortoises (gopher)/light anesthesia; tracheal intubation;<br>inconsistent results |
|                               | (K) 5-10 mg/kg<br>IM + (M) 0.1-<br>0.15 mg/kg IM,<br>IV <sup>111</sup>            | Tortoises (small-medium)                                                          |
|                               | (K) 7.5 mg/kg +<br>(M) 0.075 mg/kg<br>IM <sup>236</sup>                           | Tortoises (gopher)/anesthesia; tracheal intubation                                |
|                               | (K) 10-20 mg/kg<br>IM + (M) 0.15-<br>0.3 mg/kg IM,<br>IV <sup>111</sup>           | Turtles (fresh water)                                                             |
|                               | (K) 5-10 mg/kg +<br>(M) 0.1-0.15<br>mg/kg IM <sup>114</sup>                       | Alligators/adults                                                                 |
|                               | (K) 10-15 mg/kg<br>+ (M) 0.15-0.25<br>mg/kg IM <sup>114</sup>                     | Alligators/juveniles                                                              |
| Ketamine<br>(K)/midazolam (M) | (K) 20-40 mg/kg<br>+ (M) ≤2 mg/kg<br>IM <sup>23</sup>                             | Chelonians/sedation; muscle relaxation                                            |
|                               | (K) 60-80<br>mg/kg <sup>217</sup> + (M)<br>≤2 mg/kg IM <sup>270</sup>             | Chelonians/anesthesia; muscle relaxation                                          |
| Ketamine<br>(K)/propofol (P)  | (K) 25-30 mg/kg<br>IM <sup>217</sup> + (P) 7<br>mg/kg IV <sup>250</sup>           | Chelonians/administer propofol ≈70-80 min post-ketamine;<br>see propofol          |

|                                |                                               |                                                                                                                                                                                                                                                                                                  |
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| Lidocaine (0.5-2%)             | Local or topical <sup>270</sup>               | Most species/local analgesia; infiltrate to effect (e.g., 0.01 mL 2% lidocaine used for local block for IO catheter placement in iguanas); <sup>14</sup> often used in conjunction with chemical immobilization                                                                                  |
| Medetomidine <sup>a</sup>      | —                                             | Medetomidine is no longer commercially available, but can be compounded; <sup>a</sup> reverse with atipamezole; produces poor immobilization alone; see ketamine and butorphanol for combinations                                                                                                |
|                                | 0.1-0.15 mg/kg IM <sup>16</sup>               | Most species                                                                                                                                                                                                                                                                                     |
|                                | 0.06-0.15 mg/kg <sup>272</sup>                | Lizards                                                                                                                                                                                                                                                                                          |
|                                | 0.15 mg/kg IM <sup>277,278</sup>              | Desert tortoises, crocodilians/sedation; incomplete immobilization; generally produces bradycardia and bradypnea                                                                                                                                                                                 |
|                                | 0.04-0.15 mg/kg IM <sup>175</sup>             | Crocodilians/need to reverse                                                                                                                                                                                                                                                                     |
| Methohexital (Brevital, Lilly) | —                                             | Recovery time of red-sided garter snakes at 21°C (70°F), 125 min; 26°C (79°F), 86 min; 31°C (88°F), 64 min; thinner snakes had longer recovery times; if within 5 wk of parturition, mean recovery time 2x as long as nongravid; time post-feeding had no effect at 1, 3, 10 days <sup>248</sup> |
|                                | 5-20 mg/kg SC, <sup>13</sup> IV <sup>84</sup> | Most species/induction, 5-30 min; recovery, 1-5 hr; use at 0.125-0.5% concentration; much species variability; decrease dose 20-30% for young animals; avoid use in debilitated animals                                                                                                          |
|                                | 9-10 mg/kg SC, <sup>233</sup> ICe             | Colubrids/induction, ≥22 min; recovery, 2-5 hr; does not produce soft tissue irritation seen with other barbiturates; may need to adjust dosage in obese snakes                                                                                                                                  |
| Metomidate                     | 10 mg/kg IM <sup>65,265</sup>                 | Snakes/profound sedation; not available in the United States                                                                                                                                                                                                                                     |
| Midazolam                      | —                                             | See butorphanol, ketamine for combinations; can be reversed by flumazenil                                                                                                                                                                                                                        |
|                                | 2 mg/kg IM <sup>12,13</sup>                   | Most species/preanesthetic; increases the efficacy of ketamine; effective in snapping turtles, not in painted turtles <sup>13</sup>                                                                                                                                                              |
|                                | 0.5-2 mg/kg <sup>272</sup>                    | Lizards                                                                                                                                                                                                                                                                                          |
|                                | 1.5 mg/kg IM <sup>238</sup>                   | Turtles (red-eared sliders)/sedation; onset, 5.5 min; duration, 82 min; recovery, 40 min; much individual variability                                                                                                                                                                            |
| Naloxone                       | 4 mg/kg IM <sup>93</sup>                      | Green tree monitor/reversal of butorphanol                                                                                                                                                                                                                                                       |

|               |                                                                                                                                    |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
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| Neostigmine   | 0.03-0.25 mg/kg<br>IM <sup><a href="#">178</a></sup>                                                                               | Crocodiles/gallamine reversal; may cause emesis and lacrimation; fast 24-48 hr before use; effects enhanced if combined with 75 mg hyaluronidase per dose when administered SC, IM <sup><a href="#">178</a></sup>                                                                                                                                                                                                                                                                                                                                                                                                                                 |
|               | 0.063 mg/kg<br>IV <sup><a href="#">178</a></sup>                                                                                   |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
|               | 0.07-0.14 mg/kg<br>IM <sup><a href="#">224</a></sup>                                                                               |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
| Pentobarbital | 15-30 mg/kg<br>ICe <sup><a href="#">217</a></sup>                                                                                  | Snakes/induction, 30-60 min; duration, ≥2 hr; prolonged recovery (risk of occasional fatalities); venomous snakes require twice as much as nonvenomous snakes; <sup><a href="#">12</a></sup> avoid use in lizards                                                                                                                                                                                                                                                                                                                                                                                                                                 |
|               | 10-18 mg/kg<br>ICe <sup><a href="#">217</a></sup>                                                                                  | Chelonians                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
|               | 7.5-15 mg/kg<br>ICe, or 8 mg/kg<br>IM <sup><a href="#">12,217</a></sup>                                                            | Crocodylians                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| Propofol      | —                                                                                                                                  | If administered in supravertebral sinus, be aware for potential submeningeal delivery; <sup><a href="#">251</a></sup> see ketamine for combination; anesthesia; rapid, smooth induction; may give 15-25 min anesthesia and restraint in most species; rapid, excitement-free recovery; must be administered IV (slowly) (no inflammation if goes perivascularly); may be administered IO; dosages may be reduced by as much as 50% in premedicated (e.g., ketamine) animals; may cause apnea and bradycardia; intubation and assisted ventilation generally required; considered by many to be parenteral agent of choice for inducing anesthesia |
|               | 0.3-0.5<br>mg/kg/min IV,<br>IO constant rate<br>infusion or 0.5-1<br>mg/kg IV, IO<br>periodic bolus <sup><a href="#">273</a></sup> | Most species/maintenance anesthesia; must provide respiratory and thermal support                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
|               | 5-10 mg/kg IV,<br>IC <sup><a href="#">6,265</a></sup>                                                                              | Snakes                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
|               | 3-5 mg/kg IV,<br>IO <sup><a href="#">110,111</a></sup>                                                                             | Lizards (iguanas)/intubation and minor diagnostic procedures; may need to give an additional dose in 3-5 min; less cardiopulmonary depression than with higher doses                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
|               | 5-10 mg/kg IV,<br>IO <sup><a href="#">19</a></sup>                                                                                 | Iguanas/higher dose is recommended for induction for short duration procedures or intubation                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |

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|                               | 10 mg/kg IV, IO <sup><a href="#">19,65</a></sup>                  | Lizards, snakes/0.25 mg/kg/min may be given for maintenance <sup><a href="#">17</a></sup>                                                                                                                                                                                                                                    |
|                               | 2 mg/kg IV <sup><a href="#">16</a></sup>                          | Giant tortoises                                                                                                                                                                                                                                                                                                              |
|                               | 3-5 mg/kg IV (supravertebral sinus) <sup><a href="#">77</a></sup> | Chelonians/sedation (i.e., shell repair)                                                                                                                                                                                                                                                                                     |
|                               | 10 mg/kg IV (supravertebral sinus) <sup><a href="#">317</a></sup> | Red-eared sliders/40-85 min anesthesia                                                                                                                                                                                                                                                                                       |
|                               | 12-15 mg/kg IV <sup><a href="#">62,288</a></sup>                  | Chelonians/lower dosages (5-10 mg/kg IV) <sup><a href="#">270</a></sup> may be used; 1 mg/kg/min may be given for maintenance <sup><a href="#">270</a></sup>                                                                                                                                                                 |
|                               | 20 mg/kg IV (supravertebral sinus) <sup><a href="#">317</a></sup> | Red-eared sliders/60-120 min anesthesia                                                                                                                                                                                                                                                                                      |
|                               | 10-15 mg/kg IV <sup><a href="#">177</a></sup>                     | Crocodylians/duration, 0.5-1.5 hr; maintain on gas anesthetics; experimental IM with hyaluronidase                                                                                                                                                                                                                           |
| Rocuronium (Zemuron, Organon) | 0.25-0.5 mg/kg IM <sup><a href="#">153</a></sup>                  | Box turtles/neuromuscular blocking agent; no analgesia; for intubation only and small, non-painful procedures                                                                                                                                                                                                                |
| Sevoflurane                   | To effect <sup><a href="#">10,261</a></sup>                       | Most species/anesthesia; rapid induction and recovery when intubated                                                                                                                                                                                                                                                         |
| Succinylcholine               | —                                                                 | No analgesia; narrow margin of safety; generally not recommended, but included for completeness; intermittent positive pressure ventilation generally required; paralysis occurs in 5-30 min; avoid if exposed to organophosphate parasiticides within last 30 days; administer minimal amount required to perform procedure |
|                               | 0.25-1 mg/kg IM <sup><a href="#">142</a></sup>                    | Most species                                                                                                                                                                                                                                                                                                                 |
|                               | 0.75-1 mg/kg IM <sup><a href="#">27</a></sup>                     | Large lizards                                                                                                                                                                                                                                                                                                                |
|                               | 0.25-1.5 mg/kg IM <sup><a href="#">242,243</a></sup>              | Chelonians/induction, 15-30 min; recovery, 45-90 min; facilitates intubation                                                                                                                                                                                                                                                 |
|                               | 0.5-1 mg/kg IM <sup><a href="#">28</a></sup>                      | Box turtles/induction, 20-30 min                                                                                                                                                                                                                                                                                             |
|                               | 0.4-1 mg/kg IM <sup><a href="#">242</a></sup>                     | Alligators/rapid onset; 3-5 mg/kg in smaller animals have been used                                                                                                                                                                                                                                                          |
|                               | 0.5-5 mg/kg IM <sup><a href="#">13,175</a></sup>                  | Crocodylians/variable induction and recovery periods                                                                                                                                                                                                                                                                         |
|                               | 0.25 mg/kg IM <sup><a href="#">169</a></sup>                      | Crocodylians                                                                                                                                                                                                                                                                                                                 |
| Thiopental                    | 19-31 mg/kg IV <sup><a href="#">310</a></sup>                     | Green sea turtles/anesthesia; induction, 5-10 min; recovery, <6 hr; erratic anesthesia                                                                                                                                                                                                                                       |
|                               |                                                                   |                                                                                                                                                                                                                                                                                                                              |



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| Tiletamine/zolazepam<br>(Telazol, Fort Dodge) | —                                                                            | Sedation, anesthesia; severe respiratory depression possible (may need to ventilate); <sup>31</sup> variable results; may have prolonged recovery; use lower end of dose range in heavier species; good for muscle relaxation prior to intubation; <sup>79,256</sup> other anesthetic agents may be preferable                             |
|                                               | 4-5 mg/kg SC, IM <sup>13</sup>                                               | Most species/sedation; induction, 9-15 min; recovery, 1-12 hr; adequate for most non-invasive procedures                                                                                                                                                                                                                                   |
|                                               | 5-10 mg/kg IM <sup>16</sup>                                                  | Most species                                                                                                                                                                                                                                                                                                                               |
|                                               | 3 mg/kg IM <sup>111</sup>                                                    | Snakes/facilitates handling and intubation of large snakes; induction, 30-45 min; prolongs recovery                                                                                                                                                                                                                                        |
|                                               | 3-5 mg/kg IM <sup>220</sup>                                                  | Snakes, lizards/sedation                                                                                                                                                                                                                                                                                                                   |
|                                               | 10-30 mg/kg <sup>217</sup> to 20-40 mg/kg IM <sup>142,269</sup>              | Snakes, lizards/induction, 8-20 min; recovery, 2-10 hr; variable results; longer sedation and recovery times at 22°C (72°F) than at 30°C (86°F); <sup>292</sup> good sedation in boa constrictors at 25 mg/kg IM; <sup>292</sup> generally need to supplement with inhalation agents for surgical anesthesia; some snakes died at 55 mg/kg |
|                                               | 3.5-14 mg/kg IM <sup>217</sup> (generally 4-8 mg/kg)                         | Chelonians/sedation; induction, 8-20 min; does not produce satisfactory anesthesia even at 88 mg/kg <sup>242</sup>                                                                                                                                                                                                                         |
|                                               | 5-10 mg/kg IM, IV <sup>270</sup>                                             | Large tortoises/facilitates intubation; if light, mask with isoflurane rather than redosing                                                                                                                                                                                                                                                |
|                                               | 1-2 mg/kg IM <sup>175</sup>                                                  | Crocodylians/recovery takes several hours                                                                                                                                                                                                                                                                                                  |
|                                               | 2-10 mg/kg IM <sup>270</sup>                                                 | Large crocodylians/may permit intubation                                                                                                                                                                                                                                                                                                   |
|                                               | 5-10 mg/kg (sedation) to 10-40 mg/kg (anesthesia) SC, IM, ICe <sup>177</sup> | Crocodylians                                                                                                                                                                                                                                                                                                                               |
|                                               | 15 mg/kg IM <sup>46</sup>                                                    | Alligators/induction, >20 min; adequate for minor procedures                                                                                                                                                                                                                                                                               |
| Xylazine                                      | —                                                                            | Infrequently used; variable effects; potentially reversible with yohimbine; preanesthetic for ketamine                                                                                                                                                                                                                                     |
|                                               | 0.1-1.25 mg/kg IM, IV <sup>84</sup>                                          | Most species                                                                                                                                                                                                                                                                                                                               |
|                                               | 0.1-1 mg/kg IM <sup>175</sup>                                                | Crocodylians/atipamezole better reversal than yohimbine                                                                                                                                                                                                                                                                                    |
|                                               | 1-2 mg/kg IM <sup>177,242</sup>                                              | Nile crocodiles                                                                                                                                                                                                                                                                                                                            |
| Yohimbine (Yobine,                            |                                                                              |                                                                                                                                                                                                                                                                                                                                            |



|        |   |                                     |
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| Lloyd) | — | Xylazine reversal; rarely indicated |
|--------|---|-------------------------------------|

<sup>a</sup> Medetomidine is no longer commercially available although it can be obtained from select compounding services; dosages are listed here as a guide for possible use with dexmedetomidine, an  $\alpha_2$  agonist that is the active optical enantiomer of racemic compound medetomidine; it is used at ½ the dose of medetomidine but the same volume due to higher concentration; although the same effects would be expected as with medetomidine, there is limited data on the efficacy and safety of dexmedetomidine in reptiles, and, to date, appears to have been seldom used clinically in reptiles; the effects of the v/v use of the two drugs may not be equivalent, so the dose of dexmedetomidine may need to be adjusted based on clinical response.

TABLE 4-6 Analgesic Agents Used in Reptiles.

| Agent                             | Dosage                                                                                                      | Species/Comments                                                                                                                                                                                                                                                                |
|-----------------------------------|-------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Bupivacaine                       | 1-2 mg/kg local<br>q4-12h prn <sup>273</sup>                                                                | Most species/local anesthesia; 4 mg/kg maximum dose                                                                                                                                                                                                                             |
| Buprenorphine                     | 0.005-0.02 mg/kg<br>IM q24-48h <sup>109</sup>                                                               | Most species/analgesia                                                                                                                                                                                                                                                          |
|                                   | 0.01 mg/kg IM <sup>174</sup>                                                                                | Most species/analgesia                                                                                                                                                                                                                                                          |
|                                   | 0.1-1 mg/kg IM <sup>18</sup>                                                                                | Most species/analgesia                                                                                                                                                                                                                                                          |
| Butorphanol                       | —                                                                                                           | Recent studies call into question use of particular doses or of this drug in general in providing analgesia in reptiles, including red-eared sliders, ball pythons, bearded dragons and green iguanas; respiratory depression may be noted at high doses <sup>268,275,276</sup> |
|                                   | 0.4-1 mg/kg SC,<br>IM <sup>270</sup>                                                                        | Most species/analgesia; sedation; preanesthetic; 0.2 mg/kg IM used experimentally in tortoises <sup>95</sup>                                                                                                                                                                    |
|                                   | 1-2 mg/kg IM <sup>18</sup>                                                                                  | Snakes/analgesia                                                                                                                                                                                                                                                                |
|                                   | 20 mg/kg IM <sup>274</sup>                                                                                  | Corn snakes/potential analgesia                                                                                                                                                                                                                                                 |
| Carprofen<br>(Rimadyl,<br>Pfizer) | 1-4 mg/kg PO, SC,<br>IM, IV q24h, <sup>174</sup><br>follow with half<br>the dose q24-<br>72h <sup>208</sup> | Most species/analgesia; nonsteroidal antiinflammatory                                                                                                                                                                                                                           |
| Etodolac                          | 5 mg/kg PO q72h<br>× 30 days <sup>240</sup>                                                                 | Komodo dragon                                                                                                                                                                                                                                                                   |
|                                   | 2.5 µg/h patch to                                                                                           | Prehensile-tailed skinks/no side-effects reported after 24 hr when                                                                                                                                                                                                              |

|                    |                                                     |                                                                                                                                                                                                                 |
|--------------------|-----------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Fentanyl           | caudodorsal lumbar region <sup>89</sup>             | skink blood levels reached human therapeutic levels; environmental temperature can significantly affect absorption                                                                                              |
| Flunixin meglumine | 0.1-0.5 mg/kg IM q12-24h <sup>174</sup>             | Most species/nonsteroidal antiinflammatory; analgesia; use for maximum of 3 days                                                                                                                                |
|                    | 1-2 mg/kg IM q24h × 2 treatments <sup>30,283</sup>  | Lizards/nonsteroidal antiinflammatory; postsurgical analgesia                                                                                                                                                   |
|                    | 0.5-2 mg/kg IM q12-24h <sup>273</sup>               | Most species/nonsteroidal antiinflammatory; analgesia                                                                                                                                                           |
| Ketoprofen         | 2 mg/kg SC, IM q24h <sup>174</sup>                  | Most species/nonsteroidal antiinflammatory; analgesia; in green iguanas, IM, IV q24h administration at this dose may be too frequent based on PK study <sup>301</sup>                                           |
| Lidocaine (0.5-2%) | 2-5 mg/kg local <sup>273</sup>                      | Most species/10 mg/kg maximum dosage                                                                                                                                                                            |
|                    | Local or topical <sup>270</sup>                     | Most species/local analgesia; infiltrate to effect (e.g., 0.01 mL 2% lidocaine used for local block for IO catheter placement in iguanas); <sup>14</sup> often used in conjunction with chemical immobilization |
| Meloxicam          | 0.1-0.5 mg/kg PO, SC q24-48h <sup>145-147</sup>     | Most species                                                                                                                                                                                                    |
|                    | 0.2 mg/kg PO, IV q24h <sup>67</sup>                 | Green iguanas/PD                                                                                                                                                                                                |
|                    | 0.5 mg/kg PO, IM or 0.22 mg/kg IV <sup>260</sup>    | Red-eared sliders/PK; found better absorption IM vs PO; <sup>260</sup> after IV administration, plasma levels decreased rapidly and the elimination half-life was 7.57 hr                                       |
|                    | 0.1-0.2 mg/kg PO, IM q24h × 4-10 days <sup>77</sup> | Chelonians                                                                                                                                                                                                      |
| Meperidine         | 5-10 mg/kg IM q12-24h <sup>109</sup>                | Most species/analgesia; no noticeable effect in snakes even at 200 mg/kg                                                                                                                                        |
|                    | 20 mg/kg IM q12-24h <sup>174</sup>                  | Most species/analgesia                                                                                                                                                                                          |
|                    | 2-4 mg/kg ICe q6-8h <sup>145</sup>                  | Lizards                                                                                                                                                                                                         |
|                    | 2-4 mg/kg ICe <sup>3</sup>                          | Nile crocodiles/analgesia                                                                                                                                                                                       |
| Morphine           | —                                                   | No effective dose for analgesia noted in corn snakes <sup>276</sup>                                                                                                                                             |
|                    | 1.5-6.5 mg/kg IM <sup>77,274-276</sup>              | Red-eared sliders (long lasting respiratory depression), freshwater crocodiles, <i>Anolis</i> lizards/may be effective thermal analgesia in bearded dragons                                                     |
|                    | 10 mg/kg IM <sup>276</sup>                          |                                                                                                                                                                                                                 |

|                                            |                                                 |                                                                                                                                           |
|--------------------------------------------|-------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------|
|                                            | 0.5-4 mg/kg<br>ICe <sup>278</sup>               | Crocodylians/analgesia                                                                                                                    |
| Oxymorphone                                | 0.025-0.1 mg/kg<br>IV <sup>84</sup>             | Some species/analgesia; avoid in cases with hepatic or renal dysfunction; no noticeable effect in snakes, even at 1.5 mg/kg <sup>12</sup> |
|                                            | 0.05-0.2 mg/kg<br>SC, IM q12-48h <sup>109</sup> |                                                                                                                                           |
|                                            | 0.5-1.5 mg/kg<br>IM <sup>84</sup>               | See above                                                                                                                                 |
| Pentazocine<br>(Talwin,<br>Upjohn)         | 2-5 mg/kg IM q6-24h <sup>109</sup>              | Analgesia                                                                                                                                 |
| Pethidine                                  | —                                               | See meperidine                                                                                                                            |
| Prednisolone                               | 2-5 mg/kg PO,<br>IM <sup>174</sup>              | Most species/analgesia (chronic pain)                                                                                                     |
| Proparacaine<br>(Ophthaine,<br>Fort Dodge) | Topical to eye <sup>186</sup>                   | Iguanas/desensitizes surface of eye; ineffective in animals with spectacles; do not exceed toxic dose 2 mg/kg <sup>96</sup>               |
| Tramadol                                   | 11 mg/kg PO <sup>102</sup>                      | Bearded dragons                                                                                                                           |
|                                            | 5-10 mg/kg PO <sup>8</sup>                      | Red-eared sliders/thermal analgesia, higher doses may affect ventilation                                                                  |

TABLE 4-7 Hormones and Steroids Used in Reptiles.

| Agent                                           | Dosage                                                                                                | Species/Comments                                                                                                                                                                                                                               |
|-------------------------------------------------|-------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Arginine vasotocin<br>(AVT) (Sigma<br>Chemical) | 0.01-1 µg/kg IV<br>(preferred), ICe <sup>176</sup><br>q12-24h × several<br>treatments                 | Most species/dystocias; administer 30-60 min after Ca lactate/Ca glycerophosphate; more effective in reptiles than oxytocin but not commercially available for use in animals; higher doses have been reported; 0.5 µg/kg commonly recommended |
| Calcitonin                                      | 1.5 U/kg SC q8h × 14-21 days prn <sup>84</sup><br><br>50 U/kg IM, repeat in 14 days <sup>15,291</sup> | Most species (e.g., iguanas)/severe nutritional secondary hyperparathyroidism; administer after Ca supplementation; do not give if hypocalcemic                                                                                                |
|                                                 | 50 U/kg q7d × 2-3 doses <sup>182,187</sup>                                                            | Green iguanas/salmon calcitonin; do not give if hypocalcemic                                                                                                                                                                                   |
| Dexamethasone                                   | 0.6-1.25 mg/kg IM,<br>IV <sup>84</sup>                                                                | Most species/shock (septic/traumatic)                                                                                                                                                                                                          |

|                                                       |                                                                                                                           |                                                                                                                                                                                        |
|-------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                                                       | 2-4 mg/kg IM, IV q24h × 3 days <sup><a href="#">271</a></sup>                                                             | Most species/inflammatory, noninfectious respiratory disease                                                                                                                           |
|                                                       | 0.3-1.5 mg/kg IM, IV, IO <sup><a href="#">147</a></sup>                                                                   | Chelonians/hyperthermia                                                                                                                                                                |
| Dexamethasone sodium phosphate                        | 0.1-0.25 mg/kg SC, IM, IV <sup><a href="#">92</a></sup>                                                                   | Most species/shock (septic/traumatic)                                                                                                                                                  |
| Insulin                                               | 1-5 U/kg IM, ICe q24-72h <sup><a href="#">285</a></sup>                                                                   | Snakes, chelonians/doses are empirical and must be adjusted based on response to therapy and serial blood glucose; doses administered ICe may take 24-48 hr before a response is noted |
|                                                       | 5-10 U/kg IM, ICe q24-72h <sup><a href="#">285</a></sup>                                                                  | Lizards, crocodilians/see above                                                                                                                                                        |
| Leuprolide acetate (Lupron Depot 1.875 mg/mL, Abbott) | 0.4 mg/kg IM <sup><a href="#">155</a></sup>                                                                               | Iguanas/did not suppress testosterone levels in males                                                                                                                                  |
| Levothyroxine                                         | 0.02 mg/kg PO q48h <sup><a href="#">235</a></sup>                                                                         | Tortoises/hypothyroidism; stimulates feeding in debilitated tortoises                                                                                                                  |
|                                                       | 0.025 mg/kg q24h in AM <sup><a href="#">81</a></sup>                                                                      | Tortoises/monitor T <sub>4</sub> levels                                                                                                                                                |
| Methylprednisolone                                    | 1 mg/kg IV q24h <sup><a href="#">147</a></sup>                                                                            | Chelonians/ivermectin toxicity                                                                                                                                                         |
| Nandrolone (Deca-Durabolin, Orgamon)                  | 0.5-5 mg/kg IM q7-28d <sup><a href="#">120</a></sup>                                                                      | Most species/hepatic lipidosis                                                                                                                                                         |
|                                                       | 1 mg/kg IM q7-28d <sup><a href="#">63</a></sup>                                                                           | Lizards/anabolic steroid; reduces protein catabolism; may stimulate erythropoiesis                                                                                                     |
| Oxytocin                                              | —                                                                                                                         | Dystocias; results are variable; works well in chelonians, less so in snakes and lizards; generally administer 1 hr after Ca administration; use multiple doses with caution           |
|                                                       | 1-10 U/kg IM <sup><a href="#">74,143</a></sup>                                                                            | Most species/higher end of the range is commonly used; may be repeated up to 3 treatments at 90 min intervals with increasing dosage <sup><a href="#">134</a></sup>                    |
|                                                       | 2 U/kg IM q4-6h × 1-3 treatments <sup><a href="#">7</a></sup>                                                             | Most species                                                                                                                                                                           |
|                                                       | 1-5 U/kg IM, <sup><a href="#">61</a></sup> repeat in 1 hr                                                                 | Lizards/alternatively, 5 U/kg by slow IV or IO over 4-8 hr <sup><a href="#">61</a></sup>                                                                                               |
|                                                       | 1-2, <sup><a href="#">29</a></sup> 2-20, <sup><a href="#">92,204</a></sup> or 10-20 <sup><a href="#">28</a></sup> U/kg IM | Chelonians                                                                                                                                                                             |
|                                                       | 1-20 U/kg IM q90min × 3 treatments at increased doses or 50-                                                              | Chelonians                                                                                                                                                                             |

|                                                                   |                                                                                     |                                                                                                                  |
|-------------------------------------------------------------------|-------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------|
|                                                                   | 100% 1 <sup>st</sup> dose 1-12 hr later or IO drip <sup><a href="#">294</a></sup>   |                                                                                                                  |
| Prednisolone                                                      | 2-5 mg/kg PO, IM <sup><a href="#">174</a></sup>                                     | Most species/analgesia (chronic pain)                                                                            |
|                                                                   | 0.5 mg/kg q24h × 14 days, then q48h until PCV stable <sup><a href="#">145</a></sup> | Lizards/auto-immune hemolytic anemia                                                                             |
| Prednisolone Na succinate (Solu-Delta Cortef, Pharmacia & Upjohn) | 5-10 mg/kg IM, IV, <sup><a href="#">78</a></sup> IO <sup><a href="#">63</a></sup>   | Most species/shock; brain swelling from hyperthermia; may help reduce nephrocalcinosis                           |
| Prednisone                                                        | 0.5-1 mg/kg PO, SC, IM, IV <sup><a href="#">203</a></sup>                           | Most species/lymphoma, leukemia, myeloproliferative disease                                                      |
|                                                                   | 0.8 mg/kg q48h <sup><a href="#">93</a></sup>                                        | Most species/chronic T-lymphocytic leukemia; may combine with chlorambucil, but need to monitor uric acid levels |
| Stanozolol (Winstrol-V, Winthrop)                                 | 5 mg/kg IM q7d prn <sup><a href="#">92</a></sup>                                    | Most species/anabolic steroid; management of catabolic disease states                                            |

TABLE 4-8 Nutritional/Mineral/Fluid Support Used in Reptiles.<sup>[a](#)</sup>

| Agent                                                                                                  | Dosage                                                                                           | Species/Comments                                                                                                                                                      |
|--------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Calcium                                                                                                | PO prn <sup><a href="#">69</a></sup>                                                             | Most species/dietary sources include crushed cuttlebone, oyster shell, egg shell, tablets of Ca salts, or other commercially available products                       |
| Calcium carbonate (Rep-Cal, Rep-Cal Labs; Repti Calcium, Zoo Med)                                      | PO prn <sup><a href="#">69</a></sup>                                                             | Omnivores, herbivores, insectivores/dietary Ca supplement                                                                                                             |
| Calcium glubionate (Neo-Calglucon, Sandoz; Calciquid, Breckenridge Pharmaceuticals; Calcionate, Rugby) | 10 mg/kg PO q12-24h prn <sup><a href="#">87</a></sup>                                            | All species/nutritional secondary hyperparathyroidism                                                                                                                 |
|                                                                                                        | 360 mg/kg (1 mL/kg) PO q12-24h prn <sup><a href="#">15,31</a></sup>                              | Most species/nutritional secondary hyperparathyroidism; hypocalcemia; dystocia; ensure adequate UVB exposure and proper nutrition                                     |
| Calcium gluconate                                                                                      | 100 mg/kg SC, IM, ICe <sup><a href="#">234,259</a></sup> q6-24h <sup><a href="#">15,31</a></sup> | Most species/hypocalcemia (low ionized Ca); hypocalcemic muscle tremors, seizures, dystocia, or flaccid paresis in lizards; when patient is stable, switch to oral Ca |
| Calcium gluconate/borogluconate                                                                        | 10-50 mg/kg SC, IM <sup><a href="#">87</a></sup>                                                 | Most species/hypocalcemia; hypocalcemic dystocia                                                                                                                      |
| Calcium                                                                                                | 1-5 mg/kg SC, IM <sup><a href="#">87</a></sup>                                                   | Most species/hypocalcemia; hypocalcemic                                                                                                                               |

|                                                                 |                                                                                   |                                                                                                                                                                                                                                                                                                         |
|-----------------------------------------------------------------|-----------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| glycerophosphate/calcium lactate (Calphosan, Glenwood)          |                                                                                   | dystocia                                                                                                                                                                                                                                                                                                |
|                                                                 | 10-25 mg/kg SC, IM <sup><a href="#">92</a></sup>                                  | Most species/hypocalcemia; dystocia                                                                                                                                                                                                                                                                     |
|                                                                 | 10 mg/kg SC, IM, ICe q24h × 1-7 days <sup><a href="#">10,15</a></sup>             | Lizards (iguanas)/hypocalcemia                                                                                                                                                                                                                                                                          |
| Carnivore Care (Oxbow Animal Health)                            | 10-20 mL/kg PO or via gavage/esophagostomy q24-48h <sup><a href="#">95</a></sup>  | Carnivorous species/short-term nutritional support; anorexia; prepare according to directions; begin after rehydration and stable condition; more dilute in first feeding after anorexia, gradually increase concentration over 3-5 days                                                                |
| Clinicare—feline and canine (Abbott Animal Health)              | Gavage prn <sup><a href="#">312</a></sup>                                         | Most species/post omphalectomy; use Canine Formula for herbivores and omnivores, and Feline Formula for carnivores; initially dilute 1:1 with water and gradually increase to full strength over 48 hr; generally precede nutritional supplementation with 48-96 hr of water or electrolyte solution PO |
| Critical Care for Herbivores (Oxbow Animal Health)              | 10-20 mL/kg PO or via gavage/esophagostomy q24-48h <sup><a href="#">95</a></sup>  | Herbivorous species/long-term nutritional support; prepare according to directions; begin after rehydration and stable condition                                                                                                                                                                        |
| Dextrose in water (2.5%, 5%)                                    | PO, SC, IV, IO, ICe, EpiCe, prn <sup><a href="#">154</a></sup>                    | All species/hyperkalemia; <sup><a href="#">154</a></sup> can mix with electrolyte solutions                                                                                                                                                                                                             |
|                                                                 | Calculated water deficit IV, IO <sup><a href="#">191</a></sup>                    | Most species/for intracellular rehydration when mentation is altered and plasma Na >160 mEq/L; for acute Na toxicosis replace deficit in 12-24 hr; for chronic dehydration slowly replace deficit over 48-72 hr                                                                                         |
| Electrolyte solutions (Pedialyte, Abbott; Gatorade, S-VC, Inc.) | Voluntary drinking (whole body soak) <sup><a href="#">95</a></sup>                | All species/oral fluid therapy; early treatment of anorexia; dilute 1:1 with water; caution against drowning                                                                                                                                                                                            |
|                                                                 | 10-20 mL/kg via gavage or esophagostomy tube q24h <sup><a href="#">95</a></sup>   | All species/rehydration; when stable; first stage in supplemental nutrition                                                                                                                                                                                                                             |
| Emeraid Exotic Carnivore (Lafeber)                              | 5-30 mL/kg via gavage or esophagostomy tube q24-72h <sup><a href="#">96</a></sup> | Carnivores/nutritional support, severely debilitated, cachectic patients; prepare according to directions; use when hydrated and stable condition; greater dilution in first few feedings                                                                                                               |
| Emeraid Herbivore (Lafeber)                                     | 5-20 mL/kg via gavage or esophagostomy tube q12-48h <sup><a href="#">96</a></sup> | Herbivores/nutritional support, severely debilitated, cachectic patients; prepare according to directions; use when hydrated and stable condition; greater dilution in first few feedings                                                                                                               |
|                                                                 |                                                                                   |                                                                                                                                                                                                                                                                                                         |



|                                                                           |                                                                              |                                                                                                                                                                                                                                                                                              |
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| Emeraid Omnivore (Lafeber)                                                | 5-20 mL/kg via gavage or esophagostomy tube q12-48h <sup>95</sup>            | Most species/nutritional support, severely debilitated, cachectic patients; prepare according to directions; use when hydrated and stable condition; greater dilution in first few feedings                                                                                                  |
| Hydroxyethyl starch (Hetastarch; HES)                                     | 3-5 mL/kg slow IV or IO bolus prn <sup>95,191</sup>                          | All species/hypoalbuminemia; hypovolemic perfusion deficits; increased capillary permeability; use with crystalloids; reduce crystalloid volume 40-60%; max volume 20 mL/kg <sup>303</sup>                                                                                                   |
| Iodine                                                                    | 2-4 mg/kg PO q24h × 14-21 days, then q7d <sup>92</sup>                       | Herbivorous species/iodine deficiency (i.e., goiter); use in species fed a goitrogenic diet; can use a multivitamin-mineral mixture or iodized salt; suggested daily dietary iodine 0.03 mg/kg BW <sup>69</sup>                                                                              |
| Iron dextran                                                              | 12 mg/kg IM 1-2 ×/wk × 45 days <sup>293</sup>                                | Crocodilians/iron deficiency; in other species for anemia <sup>96</sup>                                                                                                                                                                                                                      |
| Lactated Ringer's solution (LRS)                                          | 15-40 mL/kg SC, IV, IO prn <sup>191</sup>                                    | Land turtles/fluid replacement; use extracoelomically after warming the patient; avoid lactate if hepatic insufficiency                                                                                                                                                                      |
| Maintenance crystalloid solution: ½-strength LRS and 2.5% dextrose        | SC, IV, IO, ICe, EpiCe, prn <sup>191</sup>                                   | All species/maintenance fluid therapy after losses have been replaced                                                                                                                                                                                                                        |
| Metronidazole                                                             | 12.5-50 mg/kg PO <sup>83</sup>                                               | Most species/appetite stimulant                                                                                                                                                                                                                                                              |
|                                                                           | 50-100 mg/kg PO <sup>144</sup>                                               | Chameleons/appetite stimulant                                                                                                                                                                                                                                                                |
| Polymerized bovine hemoglobin (Oxyglobin, OPK Biotech)                    | 3-5 mL/kg slow IV or IO bolus prn <sup>95,191</sup>                          | All species/hemoglobin polymer; hypoalbuminemia; hemorrhage; severe anemia; hypovolemic perfusion deficits; increased capillary permeability; use with crystalloids; reduce crystalloid volume 40-60%; max volume 20 mL/kg; <sup>303</sup> currently under FDA testing by a new manufacturer |
| Replacement crystalloid solutions (Normosol-R, Ceva; Plasma-Lyte, Baxter) | 10-30 mL/kg q24h or divided into 2-3 boluses several hr apart <sup>154</sup> | All species/ongoing regurgitation or severe diarrhea                                                                                                                                                                                                                                         |
|                                                                           | 15-25 mL/kg/d PO, SC, IV, IO, ICe, EpiCe prn <sup>30</sup>                   | All species/replacement fluid therapy; warm to 29°C (84°F) <sup>191</sup>                                                                                                                                                                                                                    |
| ReptiVite (Zoo Med)                                                       | Dust on vegetables, fruits, or insects q84-168h <sup>281</sup>               | Herbivores, omnivores, insectivores/pre-formed vitamin A; minerals; multivitamin                                                                                                                                                                                                             |
| Ringer's solution for reptiles:                                           | 10-20 mL/kg q24h <sup>141</sup>                                              | All species/hypertonic dehydration or to prevent                                                                                                                                                                                                                                             |

|                                                                                                                                               |                                                                                                     |                                                                                                                                                                                                                                                 |
|-----------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1 part Normosol-R + 2 parts 2.5% dextrose in 0.45% saline <sup>141</sup><br>or<br>1 part Normosol-R + 1 part 5% dextrose + 1 part 0.9% saline | 15 (large reptiles) to 25 (small reptiles) mL/kg q24h or divided into 2 doses per day <sup>30</sup> | nephrotoxicity due to aminoglycosides<br>All species/hypertonic dehydration; warm fluids to 28°C (82°F)                                                                                                                                         |
|                                                                                                                                               | 20 mL/kg q12h <sup>31</sup>                                                                         | Chelonians/severe dehydration                                                                                                                                                                                                                   |
| Selenium                                                                                                                                      | 0.028 mg/kg IM <sup>10</sup>                                                                        | Lizards/deficiency; myopathy                                                                                                                                                                                                                    |
| Sodium chloride (0.45%)                                                                                                                       | PO, SC, IV, IO, ICe, EpiCe, prn <sup>154</sup>                                                      | All species/hypertonic dehydration; correct deficits over 3 days                                                                                                                                                                                |
| Sodium chloride (0.9%)                                                                                                                        | SC, IV, IO, ICe, EpiCe, prn <sup>154,191</sup>                                                      | All species/hyperkalemia, hypercalcemia, hypochloremic metabolic alkalosis; <sup>191</sup> can mix with other crystalloid solutions, particularly 5% dextrose; use SC, ICe, EpiCe routes after patient is warm                                  |
| Vitamin A                                                                                                                                     | —                                                                                                   | Overdose causes epidermal sloughing; greater risk with aqueous parenteral formulation; for less severe cases, commercial formulated diets or reptile multivitamin supplements may suffice; <sup>69,218,281</sup> may help infectious stomatitis |
|                                                                                                                                               | 1000-5000 U/kg IM q7-10d × 4 treatments <sup>92</sup>                                               | Most species/hypovitaminosis A                                                                                                                                                                                                                  |
|                                                                                                                                               | 2000 U/kg PO, SC, IM q7-14d × 2-4 treatments <sup>28,31</sup>                                       | Most species/hypovitaminosis A                                                                                                                                                                                                                  |
|                                                                                                                                               | 2000 U/30 g BW PO once, repeat in 7 days <sup>105,281</sup>                                         | Chameleons/eye swelling, respiratory disease, hemipenile plugs, dysecdysis                                                                                                                                                                      |
|                                                                                                                                               | 200-300 U/kg <sup>69</sup> SC, IM                                                                   | Turtles/hypovitaminosis A; give in conjunction with PO vitamin A (2-8 U/g feed DM)                                                                                                                                                              |
| Vitamins A,D <sub>3</sub> ,E (Vital E+A+D, Stuart Products)                                                                                   | 0.15 mL/kg IM, repeat in 21 days <sup>143</sup>                                                     | Most species/hypovitaminosis A, D <sub>3</sub> , or E; product contains alcohol and may sting when administered; a product without alcohol can be compounded commercially                                                                       |
|                                                                                                                                               | 0.3 mL/kg PO, then 0.06 mL/kg q7d × 3-4 treatments <sup>28</sup>                                    | Box turtles/hypovitaminosis A; parenteral use may result in hypervitaminosis A and D; given PO may enhance Ca uptake                                                                                                                            |
| Vitamin B complex                                                                                                                             | 0.3 mL/kg SC, IM q24h <sup>96</sup>                                                                 | Most species/anorexia; hypovitaminosis B                                                                                                                                                                                                        |
|                                                                                                                                               | 25 mg thiamine/kg PO q24h × 3-7 days <sup>7</sup>                                                   | Most species/appetite stimulant; hypovitaminosis B                                                                                                                                                                                              |
|                                                                                                                                               |                                                                                                     |                                                                                                                                                                                                                                                 |



|                                          |                                                                       |                                                                                                                                |
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| Vitamin B <sub>1</sub> (thiamine)        | 50-100 mg/kg PO, SC, IM q24h <sup><a href="#">36</a></sup>            | Piscivores/thiamine deficiency from thawed fish                                                                                |
|                                          | 30 g/kg feed fish PO <sup><a href="#">92</a></sup>                    | Crocodilians/treat or prevent deficiency                                                                                       |
| Vitamin B <sub>12</sub> (cyanocobalamin) | 0.05 mg/kg SC, IM <sup><a href="#">92</a></sup>                       | Snakes, lizards/appetite stimulant                                                                                             |
| Vitamin C                                | 10-20 mg/kg SC, IM q24h <sup><a href="#">82,212</a></sup>             | All species/hypovitaminosis C; stomatitis; skin slough in snakes; supportive therapy for bacterial infections                  |
| Vitamin D <sub>3</sub>                   | —                                                                     | Nutritional secondary hyperparathyroidism; hypocalcemia; deficiency and excess may result in soft-tissue calcification         |
|                                          | 1000 U/kg IM, repeat in 1 wk <sup><a href="#">31</a></sup>            | Most species/deficiency; use with oral calcium glubionate and carbonate, general dietary management, and UVB irradiation       |
|                                          | 200 U/kg PO, IM q7d <sup><a href="#">10,15</a></sup>                  | Lizards/PO may be safer than IM, but absorption is poor in some species <sup><a href="#">21,237</a></sup>                      |
|                                          | 400 U/kg IM q7d × 3 treatments <sup><a href="#">187</a></sup>         | Green iguanas/nutritional secondary hyperparathyroidism; use with calcitonin after normocalcemic; also supplement oral calcium |
| Vitamin E/selenium (L-Se, Schering)      | 1 U vitamin E/kg <sup><a href="#">69</a></sup> IM                     | Piscivores/hypovitaminosis E; myopathy, anorexia, swollen subcutaneous nodules                                                 |
|                                          | 50 U vit E/kg + 0.025 mg selenium/kg IM <sup><a href="#">73</a></sup> | Lizards/hypovitaminosis E (vitamin E/selenium)                                                                                 |
| Vitamin K <sub>1</sub>                   | 0.25-0.5 mg/kg IM <sup><a href="#">143</a></sup>                      | Most species/hypovitaminosis K <sub>1</sub> ; coagulopathies                                                                   |

<sup>a</sup> Also see [Table 4-13](#).

TABLE 4-9 Miscellaneous Agents Used in Reptiles.

| Agent                                | Dosage                                                               | Species/Comments                                                                                                                                     |
|--------------------------------------|----------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------|
| Allopurinol                          | —                                                                    | Careful when giving with urine acidifiers and uricosuric drugs (probenecid) <sup><a href="#">54</a></sup>                                            |
|                                      | 10-20 mg/kg PO q24h <sup><a href="#">63,204,252</a></sup>            | Most species/gout; decreases production of uric acid; <sup><a href="#">183</a></sup> long-term therapy; tortoises may respond best                   |
|                                      | 25 mg/kg PO q24h <sup><a href="#">122</a></sup>                      | Green iguanas                                                                                                                                        |
|                                      | 50 mg/kg PO q24h × 30 days, then q72h <sup><a href="#">165</a></sup> | Chelonians/hyperuricemia                                                                                                                             |
| Aluminum hydroxide (Amphogel, Wyeth- | 100 mg/kg PO q12-24h <sup><a href="#">183</a></sup>                  | Most species/hyperphosphatemia (associated with renal disease); decreases intestinal absorption of P; use cautiously in patients with gastric outlet |

|                                                 |                                                                                                                           |                                                                                                                                                                                                        |
|-------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Ayerst)                                         |                                                                                                                           | obstruction                                                                                                                                                                                            |
| Amidotrizoate<br>(Gastrografin,<br>Squibb)      | 7.5 mL/kg PO <sup><a href="#">215</a></sup>                                                                               | Tortoises/gastrointestinal contrast agent; give via gavage; mean transit times: 2.6 hr at 30.6°C (87°F); 6.6 hr at 21.5°C (71°F)                                                                       |
| Aminophylline                                   | 2-4 mg/kg IM <sup><a href="#">84</a></sup>                                                                                | Most species/bronchodilator                                                                                                                                                                            |
| Atropine                                        | 0.01-0.04 mg/kg IM, IV<br>q8-24h <sup><a href="#">214</a></sup>                                                           | Most species/dries up excess mucous secretions with infectious stomatitis                                                                                                                              |
|                                                 | 0.1-0.2 mg/kg IM prn <sup><a href="#">143</a></sup>                                                                       | Most species/organophosphate toxicity                                                                                                                                                                  |
|                                                 | 0.2 mg/kg SC, IM <sup><a href="#">264</a></sup>                                                                           | Most species/respiratory distress associated with excessive secretions                                                                                                                                 |
| Barium sulfate                                  | 5-20 mL/kg PO <sup><a href="#">37</a></sup>                                                                               | Most species/gastrointestinal contrast studies                                                                                                                                                         |
| Calcium EDTA                                    | 10-40 mg/kg IM q12h <sup><a href="#">234</a></sup>                                                                        | Most species/heavy metal chelation; ensure hydration                                                                                                                                                   |
| Carboplatin                                     | 2.5-5 mg/kg IV,<br>intracardiac <sup><a href="#">203</a></sup>                                                            | Most species/carcinoma, osteosarcoma, mesothelioma, carcinomatosis                                                                                                                                     |
| Chlorambucil<br>(Leukeran, Glaxo<br>SmithKline) | 0.1-0.2 mg/kg PO <sup><a href="#">203</a></sup>                                                                           | Most species/lymphoma, leukemia, myeloproliferative tumors                                                                                                                                             |
| Cimetidine                                      | 4 mg/kg PO, IM q8-12h <sup><a href="#">92</a></sup>                                                                       | Most species/gastric and duodenal ulceration; esophagitis; gastroesophageal reflux; may use in renal failure to increase phosphate secretion                                                           |
| Cisapride (Propulsid,<br>Janssen)               | 0.5-2 mg/kg PO q24h <sup><a href="#">291</a></sup>                                                                        | Most species/motility modifier; gastrointestinal stasis; not commercially available in the United States; may be compounded; ineffective in desert tortoises at 1 mg/kg <sup><a href="#">299</a></sup> |
| Cisplatin                                       | 0.5-1 mg/kg IV (pre-hydrate), IC, intralesional (in oil) <sup><a href="#">203</a></sup>                                   | Most species/carcinoma, osteosarcoma, infiltrative sarcoma (intralesional), mesothelioma, carcinomatosis                                                                                               |
| Cyclophosphamide                                | 10 mg/kg SC, IM, IV,<br>IC <sup><a href="#">203</a></sup>                                                                 | Most species/lymphoma, leukemia, myeloproliferative tumors                                                                                                                                             |
| Dioctyl Na<br>sulfosuccinate                    | 1-5 mg/kg PO <sup><a href="#">98</a></sup>                                                                                | Most species/constipation; use 1:20 dilution                                                                                                                                                           |
| Doxorubicin                                     | 1 mg/kg IV q7d × 2<br>treatments, then q14d × 2<br>treatments, then q21d × 2<br>treatments <sup><a href="#">262</a></sup> | Snakes/chemotherapy for sarcoma (also lymphoma, carcinoma, etc.); treatment periods variable                                                                                                           |
| Furosemide                                      | 2-5 mg/kg PO, IM, IV<br>q12-24h <sup><a href="#">92,143,145-147</a></sup>                                                 | Most species/diuretic for edema and pulmonary congestion, while lacking loop of Henle, may effect via other mechanisms                                                                                 |
| Hydrochlorothiazide                             | 1 mg/kg q24-72h <sup><a href="#">63</a></sup>                                                                             | Lizards/promotes diuresis; monitor hydration status                                                                                                                                                    |
| Iodine compound                                 |                                                                                                                           |                                                                                                                                                                                                        |

|                                                             |                                                                               |                                                                                                                                                                                                             |
|-------------------------------------------------------------|-------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| (Conray 280, Mallinckrodt)                                  | 500 mg/kg IV, IO <sup><a href="#">63</a></sup>                                | Lizards/IV urography; take radiographs 0, 5, 15, 30, and 60 min postinjection                                                                                                                               |
| Iohexol (240 mg I/mL; Omnipaque, Sanofi Winthrop)           | 5-20 mL/kg PO <sup><a href="#">38</a></sup>                                   | Most species/gastrointestinal contrast studies; nonionic, organic iodine solution; good alternative to barium; <sup><a href="#">37</a></sup> faster transit time than barium; can be diluted 1:1 with water |
| K-Y jelly (Johnson & Johnson)                               | 1-3 mL of 50% K-Y jelly and 50% warm water/100 g <sup><a href="#">5</a></sup> | Most species/enema                                                                                                                                                                                          |
| Lactulose                                                   | 0.5 mL/kg PO q24h <sup><a href="#">145,147,284</a></sup>                      | Lizards, chelonians/hepatic lipidosis                                                                                                                                                                       |
| L-asparaginase (Elspar, Merck)                              | 400 U/kg SC, IM, IC <sup><a href="#">203</a></sup>                            | Most species/lymphoma, leukemia, myeloproliferative tumors                                                                                                                                                  |
| Melphalan (Alkeran, Cellegene)                              | 0.05-0.1 mg/kg PO <sup><a href="#">203</a></sup>                              | Most species/lymphoma, leukemia, myeloproliferative tumors                                                                                                                                                  |
| Methimazole                                                 | 2 mg/kg q24h × 30 days <sup><a href="#">105</a></sup>                         | Snakes/excessive shedding from hyperthyroidism; limited effectiveness                                                                                                                                       |
| Methotrexate                                                | 0.25 mg/kg PO, SC, IV <sup><a href="#">203</a></sup>                          | Most species/lymphoma, leukemia, myeloproliferative tumors                                                                                                                                                  |
| Metoclopramide                                              | 0.06 mg/kg PO q24h × 7 days <sup><a href="#">60,291</a></sup>                 | Most species/stimulates gastric motility                                                                                                                                                                    |
|                                                             | 1-10 mg/kg PO q24h <sup><a href="#">313</a></sup>                             | Tortoises/stimulates gastric motility; ineffective in desert tortoises at 1 mg/kg <sup><a href="#">299</a></sup>                                                                                            |
| Milk thistle ( <i>Silybum marianum</i> )                    | 4-15 mg/kg PO q8-12h <sup><a href="#">145,147</a></sup>                       | Lizards, chelonians/hepatoprotectant                                                                                                                                                                        |
| Pentobarbital                                               | 60-100 mg/kg IV, ICe <sup><a href="#">4,32</a></sup>                          | Euthanasia                                                                                                                                                                                                  |
| Pimobendan                                                  | 0.2 mg/kg PO q24h <sup><a href="#">145</a></sup>                              | Lizards                                                                                                                                                                                                     |
| Potassium chloride                                          | 2 mEq/kg IV, ICe <sup><a href="#">15</a></sup>                                | Most species/euthanasia; cardioplegic; administer following a euthanasia solution                                                                                                                           |
| Probenecid                                                  | 250 mg/kg PO q12h <sup><a href="#">246</a></sup>                              | Most species/gout; increases uric acid excretion; can be increased prn                                                                                                                                      |
| S-adenosylmethionine (Denosyl, Nutramax)                    | 30 mg/kg PO q24h <sup><a href="#">228</a></sup>                               | Savannah monitors/liver disease                                                                                                                                                                             |
| Sodium bicarbonate                                          | 0.5-1 mg/kg IV <sup><a href="#">291</a></sup>                                 | Most species/hypoxic acidosis post-anesthesia                                                                                                                                                               |
| Sucralfate                                                  | 500-1000 mg/kg PO q6-8h <sup><a href="#">84</a></sup>                         | Most species/oral, esophageal, gastric, and duodenal ulcers                                                                                                                                                 |
| Tamoxifen 60-day time release pellets (Innovative Research) | Pellets containing 5 mg tamoxifen implants ICe <sup><a href="#">55</a></sup>  | Leopard geckos/inhibition of follicular development for 60 days if implanted before vitellogenesis                                                                                                          |

|             |                               |                                                            |
|-------------|-------------------------------|------------------------------------------------------------|
| of America) |                               |                                                            |
| Vincristine | 0.025 mg/kg IV <sup>203</sup> | Most species/lymphoma, leukemia, myeloproliferative tumors |

TABLE 4-10 Hematologic and Serum Biochemical Values of Reptiles.<sup>a</sup>

| Measurement                       | Boa Constrictor ( <i>Boa constrictor</i> ) <sup>15,181,202</sup> | Emerald Tree Boa ( <i>Corallus caninus</i> ) <sup>182</sup> | Rainbow Boa ( <i>Epicrates cenchria</i> ) <sup>187</sup> |
|-----------------------------------|------------------------------------------------------------------|-------------------------------------------------------------|----------------------------------------------------------|
| Hematology                        |                                                                  |                                                             |                                                          |
| PCV (%)                           | 29 (10-45)                                                       | 22.6 (6-57)                                                 | 28 (11-40)                                               |
| RBC (10 <sup>6</sup> /μL)         | 0.73 (0.16-2.1)                                                  | 2.16 (0.54-5.05)                                            | 0.92 (0.34-1.74)                                         |
| Hgb (g/dL)                        | 9 (2.6-15.3)                                                     | 8.2 (6.1-11.4)                                              | 10.6 (8-13.1)                                            |
| MCV (fL)                          | 393 (159-625)                                                    | 237 (37-360)                                                | 292 (175-534)                                            |
| MCH (pg)                          | 132 (84-208)                                                     | 120 (113-128)                                               | 160                                                      |
| MCHC (g/dL)                       | 32 (22-42)                                                       | 34 (30-36)                                                  | 36 (33-40)                                               |
| WBC (10 <sup>3</sup> /μL)         | 8.54 (0.88-22.6)                                                 | 4.35 (0.48-10.6)                                            | 7.99 (1-35.2)                                            |
| Heterophils (10 <sup>3</sup> /μL) | 2.46 (0.21-12.3)                                                 | 1.61 (0.18-5.36)                                            | 2.85 (0.03-10)                                           |
| Lymphocytes (10 <sup>3</sup> /μL) | 4.01 (0.16-18.5)                                                 | 2.48 (0.14-8.27)                                            | 3.91 (0.1-32.4)                                          |
| Monocytes (10 <sup>3</sup> /μL)   | 0.68 (0.02-6.55)                                                 | 0.45 (0.06-2.12)                                            | 0.9 (0.03-3.06)                                          |
| Azurophils (10 <sup>3</sup> /μL)  | 1.75 (0-5.76)                                                    | 0.71 (0.1-1.84)                                             | 1.08 (0.11-4.44)                                         |
| Eosinophils (10 <sup>3</sup> /μL) | 0.26 (0.03-1.22)                                                 | 0.07 (0.06-0.08)                                            | 0.11 (0.04-0.22)                                         |
| Basophils (10 <sup>3</sup> /μL)   | 0.46 (0.03-2.77)                                                 | 0.07 (0.03-0.14)                                            | 0.1 (0.02-0.27)                                          |
| Chemistries                       |                                                                  |                                                             |                                                          |
| ALP (U/L)                         | 287 (43-1342)                                                    | 128 (61-323)                                                | 27 (14-37)                                               |
| ALT (U/L)                         | 14 (0-37)                                                        | 5 (1-10)                                                    | 4 (1-6)                                                  |
| Amylase (U/L)                     | 22 (5-67)                                                        | 293 (160-470)                                               | —                                                        |
| AST (U/L)                         | 35 (3-331)                                                       | 30 (5-92)                                                   | 43 (9-136)                                               |
| Bilirubin, total (mg/dL)          | 0.2 (0-0.6)                                                      | 0.2 (0.2-0.3)                                               | 0.4 (0-0.8)                                              |
| BUN (mg/dL)                       | 5 (0-34)                                                         | 2 (0-4)                                                     | 2 (1-3)                                                  |
| Calcium (mg/dL)                   | 15.9 (9-27)                                                      | 12.7 (10.3-17.4)                                            | 13.4 (11.3-18.9)                                         |
| Chloride (mEq/L)                  | 125 (108-139)                                                    | 130 (119-138)                                               | 115 (94-128)                                             |
| Cholesterol (mg/dL)               | 131 (34-314)                                                     | 206 (116-343)                                               | 206 (140-314)                                            |
| Creatine kinase (U/L)             | 526 (53-1728)                                                    | 592 (157-985)                                               | 154 (31-745)                                             |
| Creatinine (mg/dL)                | 0.4 (0.1-1.6)                                                    | 0.6 (0.4-0.9)                                               | 0.4 (0.1-0.7)                                            |
| GGT (U/L)                         | 4 (0-10)                                                         | 2 (1-2)                                                     | 5                                                        |
| Glucose (mg/dL)                   | 37 (9-85)                                                        | 27 (5-56)                                                   | 17 (2-46)                                                |

Continued

| Measurement                  | Boa Constrictor ( <i>Boa constrictor</i> ) <sup>41,181,297</sup> | Emerald Tree Boa ( <i>Corallus caninus</i> ) <sup>297</sup> | Rainbow Boa ( <i>Epicrates cenchria</i> ) <sup>297</sup> |
|------------------------------|------------------------------------------------------------------|-------------------------------------------------------------|----------------------------------------------------------|
| Iron (µg/dL)                 | 113 (103-122)                                                    | —                                                           | —                                                        |
| LDH (U/L)                    | 235 (16-877)                                                     | 632 (76-1680)                                               | 401 (141-661)                                            |
| Lipase (U/L)                 | 2730                                                             | —                                                           | —                                                        |
| Magnesium (mEq/L)            | 2.95 (2.9-3)                                                     | —                                                           | —                                                        |
| Osmolarity (mOsm/L)          | 306                                                              | —                                                           | —                                                        |
| Phosphorus (mg/dL)           | 4.7 (2.6-11.7)                                                   | 4.1 (1.8-8)                                                 | 5.4 (3.8-7.7)                                            |
| Potassium (mEq/L)            | 5.4 (3-10)                                                       | 5 (3-8.7)                                                   | 3.2 (1.2-5)                                              |
| Protein, total (g/dL)        | 7 (4.3-10.8)                                                     | 4.5 (2.6-7.2)                                               | 6.2 (3.7-8)                                              |
| Albumin (g/dL) <sup>b</sup>  | 3.1 (1.9-5.3)                                                    | 2.6 (2-3.6)                                                 | 2.6 (1.8-3.6)                                            |
| Globulin (g/dL) <sup>b</sup> | 4 (2.2-6.9)                                                      | 2.8 (1.8-3.6)                                               | 4.1 (2.8-5.8)                                            |
| Sodium (mEq/L)               | 158 (130-171)                                                    | 157 (148-167)                                               | 155 (137-163)                                            |
| Triglyceride (mg/dL)         | 103 (3-457)                                                      | 24 (10-49)                                                  | 72 (64-90)                                               |
| Uric acid (mg/dL)            | 4.7 (0-11.9)                                                     | 4.7 (1.4-19.2)                                              | 7.2 (2.1-27.5)                                           |

TABLE 4-11 Environmental, Dietary, and Reproductive Characteristics of Reptiles. [9,53,71,106,141,211,283](#)

| Species                                         | Environmental Preference    |                                       | Diet <sup>a</sup> | Method of Reproduction <sup>b</sup> | Gestation/ Incubation Period (Days) |
|-------------------------------------------------|-----------------------------|---------------------------------------|-------------------|-------------------------------------|-------------------------------------|
|                                                 | Temperature <sup>40,c</sup> | RH (%)                                |                   |                                     |                                     |
| Snakes                                          |                             |                                       |                   |                                     |                                     |
| Ball (Royal) python<br>( <i>Python regius</i> ) | 25-30°C<br>(77-86°F)        | 70-80 (use humidity box) <sup>d</sup> | C                 | Ov                                  | 90                                  |
| Boa constrictor<br>( <i>Boa constrictor</i> )   | 28-34°C<br>(82-93°F)        | 50-70 (use humidity box) <sup>d</sup> | C                 | V                                   | 120-240                             |
| Garter snake<br>( <i>Thamnophis sirtalis</i> )  | 22-30°C<br>(72-86°F)        | 60-80 (use humidity box) <sup>d</sup> | C                 | V                                   | 90-110                              |
| King snake<br>( <i>Lampropeltis getulus</i> )   | 23-30°C<br>(73-86°F)        | 50-70 (use humidity box) <sup>d</sup> | Op/c              | Ov                                  | 50-60                               |
| Sand boa ( <i>Eryx</i> sp)                      | 25-30°C<br>(77-86°F)        | 20-30                                 | C                 | V                                   | 120-180                             |



## Lizards

|                                                           |                       |                                              |                    |    |        |
|-----------------------------------------------------------|-----------------------|----------------------------------------------|--------------------|----|--------|
| Bearded dragon<br>( <i>Pogona vitticeps</i> )             | 27-30°C<br>(80-85°F)  | —<br>(use humidity box) <sup>g</sup>         | I—young<br>H—adult | Ov | 65-90  |
| Green anole ( <i>Anolis carolinensis</i> )                | 23-29°C<br>(73-84°F)  | 70-80                                        | I/c                | Ov | 60-90  |
| Green iguana<br>( <i>Iguana iguana</i> )                  | 29-38°C<br>(84-100°F) | 60-80                                        | H                  | Ov | 73     |
| Jackson's chameleon ( <i>Chamaeleo jacksonii</i> )        | 21-27°C<br>(70-81°F)  | 50-70                                        | I                  | V  | 90-180 |
| Leopard ground gecko ( <i>Eublepharis macularius</i> )    | 25-30°C<br>(77-86°F)  | 20-30 (use humidity box) <sup>g</sup>        | I                  | Ov | 55-60  |
| Australian Water dragon ( <i>Physignathus lesueurii</i> ) | 25-34°C<br>(77-93°F)  | 80-90<br>Need water with filter <sup>h</sup> | I/om               | Ov | 90     |

Continued

| Species | Environmental Preference   |        |                   | Method of Reproduction <sup>e</sup> | Gestation/Incubation Period (Days) |
|---------|----------------------------|--------|-------------------|-------------------------------------|------------------------------------|
|         | Temperature <sup>a,c</sup> | RH (%) | Diet <sup>b</sup> |                                     |                                    |

## Chelonians

|                                                          |                      |                                              |       |    |        |
|----------------------------------------------------------|----------------------|----------------------------------------------|-------|----|--------|
| Common box turtle<br>( <i>Terrapene carolina</i> )       | 24-29°C<br>(75-84°F) | 60-80 (use humidity box) <sup>g</sup>        | C/f   | Ov | 50-90  |
| Desert tortoise<br>( <i>Gopherus agassizii</i> )         | 25-30°C<br>(77-86°F) | —<br>(use humidity box) <sup>g</sup>         | H     | Ov | 84-120 |
| Greek tortoise<br>( <i>Testudo graeca</i> )              | 20-27°C<br>(68-81°F) | 30-50 (use humidity box) <sup>g</sup>        | H/om  | Ov | 60     |
| Painted turtle<br>( <i>Chrysemys picta</i> )             | 23-28°C<br>(73-82°F) | 80-90<br>Need water with filter <sup>h</sup> | H/l/o | Ov | 47-99  |
| Red-eared slider<br>( <i>Trachemys scripta elegans</i> ) | 22-30°C<br>(72-86°F) | 80-90<br>Need water with filter <sup>h</sup> | C     | Ov | 59-93  |
| Russian tortoise<br>( <i>Testudo horsfieldii</i> )       | 21-32°C<br>(70-90°F) | —<br>(use humidity box) <sup>g</sup>         | H     | Ov | 56-84  |

| Crocodilian                                                 |                      |                                                 |     |    |       |
|-------------------------------------------------------------|----------------------|-------------------------------------------------|-----|----|-------|
| American alligator<br>( <i>Alligator mississippiensis</i> ) | 30-35°C<br>(86-95°F) | 80-90<br>Need water<br>with filter <sup>h</sup> | C/p | Ov | 62-65 |

C, v Carnivorous; F, frugivorous; H, herbivorous; I, insectivorous; O, molluscivorous; Om, omnivorous; Op, ophiophagus; P, piscivorous; RH, relative humidity; V, viviparous; Ov, oviparous.

<sup>a</sup>Temperatures shown are ideal ambient daytime temperature gradients. These should be allowed to fall by approximately 5°C (9°F) during the night. "Hot-spot" temperatures should generally be 5°C (9°F) greater than the highest temperature shown.

<sup>b</sup>Preferred daytime temperature range for other commonly housed captive snakes are: rosy boa (*Lichanura trivirgata*) = 27-29.5°C (81-85°F); green tree python (*Morelia viridis*); 24-28°C (75-82°F); carpet python (*Morelia spilota*); 27-29.5°C (81-85°F); corn snake (*Elaphe guttata*); 25-30°C (77-86°F); yellow rat snake (*Elaphe obsoleta*); 25-29°C (77-84°F); gopher/bullsnake (*Pituophis melanoleucus*); 25-29°C (77-84°F).

<sup>c</sup>Preferred daytime temperature range for other commonly housed captive lizards are: day gecko (*Phelsuma* sp); 29.5°C (85°F); chameleons (montane) (*Chamaeleo* spp); 21-27°C (70-81°F); chameleons (lowland) (*Chamaeleo* spp); 27-29°C (81-84°F); blue-tongued skink (*Tiliqua* sp); 27-29.5°C (81-85°F); monitor lizards (*Varanus* spp); 29-31°C (84-88°F); tegus (*Tupinambis* spp); 27-30°C (81-86°F).

<sup>d</sup>Uppercase letters denote principal dietary requirements. Lowercase denotes secondary preference.

<sup>e</sup>Temperature-dependent.

<sup>f</sup>Can have long hatch times dependent on incubation parameters.

<sup>g</sup>This simulates humid underground burrow. Use dark colored plastic container with cut entrance, moistened paper towels, or sphagnum moss.

<sup>h</sup>Need to set up water component like fish tank with proper filter (use one for koi or turtles), pump, water quality testing, dechlorinator.

TABLE 4-12 Urinalysis Values of Chelonians. [97](#),[133](#),[164](#),[166](#)

| Measurement                                    | Normal Values                                | Abnormal Values                                                                                                          |
|------------------------------------------------|----------------------------------------------|--------------------------------------------------------------------------------------------------------------------------|
| Specific gravity                               | 1.003-1.014 (mean, 1.008)                    | Up to 1.034                                                                                                              |
| pH                                             | Herbivores:<br>alkaline<br>Omnivores:<br>5-8 | Acidic <sup>a</sup>                                                                                                      |
| Color                                          | Colorless to pale yellow with white urates   | Dark yellow, yellow-brown, yellow-green                                                                                  |
| Turbidity                                      | Clear                                        | Cloudy                                                                                                                   |
| Protein                                        | Trace proteinuria                            | Increased proteinuria                                                                                                    |
| Glucose                                        | Glucosuria up to 30 mg/dL                    | Glucosuria can be higher than 50 mg/dL with anorexia                                                                     |
| Renal casts                                    | None                                         | Various types present                                                                                                    |
| Calcium, phosphorus, ammonia, urea, creatinine | Detectable in urine                          | Significantly increased in urine of <i>Testudo</i> spp with renal disease                                                |
| AST, CK, LDH                                   | Detectable in urine                          | Significantly increased in urine of <i>Testudo</i> spp with renal disease                                                |
| Crystals                                       | Amorphous urates/ammonium biurates           | Many other crystals found in renal failure; uric acid crystals in gout; bilirubin and tyrosine crystals in liver disease |

<sup>a</sup> May be associated with hibernation, anorexia, and improper diet.

TABLE 4-13 Selected Products and Guidelines Used in Force-Feeding Anorectic or Debilitated Reptiles.<sup>a b</sup>

| Agent                                                                                            | Guidelines                                                                                                          | Species/Comments                                                                                                                                                                                                                                                                                                                                                                                                |
|--------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Alfalfa pellets (e.g., iguana or rabbit pellets) or powder (Alfalfa Powder, NOW Foods)           | Blend (1:4) with electrolyte solution or water; 20 mL/kg PO q48h (lizards) to q84h (chelonians) <sup>29,282</sup>   | Herbivorous reptiles/administer via gavage; may clog feeding tube; for iguanas, may gavage equal volume of water on alternate days until patient is stable and eating; <sup>282</sup> soaked pellets can also be hand-fed (especially by owner)                                                                                                                                                                 |
| Baby foods                                                                                       | Vegetable; blend in with other food sources                                                                         | Herbivorous reptiles/administer via gavage; for some species, some fruit baby food can be added                                                                                                                                                                                                                                                                                                                 |
|                                                                                                  | Meat (small amount); blend in with other food sources                                                               | Omnivorous species/administer via gavage                                                                                                                                                                                                                                                                                                                                                                        |
| Dog/cat food, canned (a/d, Hill's; Maximum-Calorie Iams; Nutritional Recovery Formula, Eukanuba) | 30 mL/kg PO q7-14d <sup>38, 159</sup>                                                                               | Carnivorous species/administer via gavage; although low protein (8.5%), some concern over high purine and vitamin A levels (probably OK unless concurrent renal disease); in dehydrated animals, dilute 1:1 with physiological solution, pediatric oral human electrolyte solution (Pedialyte, Ross), or Gatorade (Gatorade); once stabilized, small whole animals (lubricated with egg white) can be force-fed |
| Electrolyte solutions (Pedialyte, Ross; Gatorade, Gatorade)                                      | 15-25 mL/kg PO q24h                                                                                                 | Most species                                                                                                                                                                                                                                                                                                                                                                                                    |
| High protein powders (Carnivore Care, Oxbow Pet Products; Emeraid Carnivore, Lafeber)            | Mix as labeled, generally to pancake batter consistency, feed small amount to start (see bag suggestion) once daily | Insectivorous and carnivorous species/once reconstituted, can be mixed 1:1 with an alfalfa or timothy product for true omnivorous reptiles; administer via gavage                                                                                                                                                                                                                                               |
| Timothy hay-based powder (Herbivore Critical Care Fine                                           | Mix as labeled, generally to pancake batter                                                                         | Herbivorous species/once reconstituted, can be mixed 1:1 with                                                                                                                                                                                                                                                                                                                                                   |



|                                                        |                                                                         |                                                                                   |
|--------------------------------------------------------|-------------------------------------------------------------------------|-----------------------------------------------------------------------------------|
| Grind, Oxbow Pet Products; Emeraid Herbivore, Lafeber) | consistency, feed small amount to start (see bag suggestion) once daily | an alfalfa or timothy product for true omnivorous reptiles; administer via gavage |
|--------------------------------------------------------|-------------------------------------------------------------------------|-----------------------------------------------------------------------------------|

<sup>a</sup> General guidelines for force-feeding: generally provide nutrition following rehydration of patient; needs may vary with specific disease (e.g., low protein with renal disease); force-feeding volumes are frequently started at a low/modest level and gradually brought up to the desired level (for patients with severe disease/cachexia, transition should be very gradual); concurrent to force-feeding and hydrating a patient, highly palatable food items should be provided for voluntary food intake.

<sup>b</sup> Dietary fiber supplements (alfalfa pellets or powder; barley powder; purified cellulose) should be an integral part of enteral therapy for herbivorous reptiles.

TABLE 4-14 Guidelines for Tracheal/Pulmonary and Colonic Lavage in Reptiles. [12,201,226](#)

| Snakes                    |                                                                                                                                                                                                                                                                                                                                                                          |
|---------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Tracheal/pulmonary lavage | Anesthesia often not necessary in debilitated animals; pass red rubber catheter through glottis to premeasured distance; infuse with 5-10 mL/kg sterile 0.9% saline; massage and rock the snake's body to loosen debris; aspirate                                                                                                                                        |
| Colonic lavage            | Pass lubricated soft red rubber catheter into cloaca; infuse with 10-20 mL/kg sterile saline; massage coelomic cavity and aspirate                                                                                                                                                                                                                                       |
| Lizards                   |                                                                                                                                                                                                                                                                                                                                                                          |
| Tracheal/pulmonary lavage | General anesthesia is typically necessary; if possible, intubate with sterile endotracheal tube; pass sterile catheter inside lumen (premeasure distance to sample site); infuse 5-10 mL/kg sterile 0.9% saline and aspirate several times; not all fluid will be recovered                                                                                              |
| Colonic lavage            | Pass lubricated soft red rubber catheter into cloaca without excessive force; infuse 10 mL/kg sterile saline and aspirate several times                                                                                                                                                                                                                                  |
| Chelonians                |                                                                                                                                                                                                                                                                                                                                                                          |
| Tracheal/pulmonary lavage | Sedation or anesthesia usually necessary; intubate with sterile endotracheal tube if possible; pass radiomarked catheter into affected lung lobe; may be helpful to bend it in the direction of the lobe prior to insertion, though location cannot be assured without orthogonal radiographic evidence of placement; infuse with sterile saline at 5-10 mL/kg; aspirate |
| Colonic lavage            | Pass lubricated red rubber catheter into cloaca; infuse with sterile saline at no more than 10 mL/kg; aspirate; repeat several times                                                                                                                                                                                                                                     |

TABLE 4-15 Venipuncture Sites Commonly Used in Reptiles. [a,119,123,258](#)

| Snakes                        |                                                                                                                                                                                                                                                                                                                                                                                                                         |
|-------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Ventral caudal vein           | Ventral aspect of tail caudal to cloaca under central scute; avoid hemipenes and anal sacs, can be difficult to collect from in boas, pythons, anacondas; may in rare cases lead to tail necrosis/paresis                                                                                                                                                                                                               |
| Heart                         | Dorsal recumbency; insertion of needle under central abdominal scale at 45° angle caudal to heart; pericardial fluid contamination can occur                                                                                                                                                                                                                                                                            |
| Lizards                       |                                                                                                                                                                                                                                                                                                                                                                                                                         |
| Ventral caudal vein           | Ventral aspect of vertebral body under center of middle scale; avoid hemipenes and anal sacs; this vein can also be approached laterally by inserting needle under lateral process of vertebral body aiming toward midline; ventral approach may in rare cases lead to tail necrosis/paresis                                                                                                                            |
| Ventral abdominal vein        | Vein is located on caudal to middle midline within inner surface of abdominal wall; insert 25-g needle (bent at 45° angle) cranially, at acute angle to skin and in midline of abdomen, just caudal to umbilicus; avoid urinary bladder in species with them                                                                                                                                                            |
| Jugular vein                  | Veins are lateral and deep; insert needle caudal to tympanum; best tried in larger animals                                                                                                                                                                                                                                                                                                                              |
| Chelonians                    |                                                                                                                                                                                                                                                                                                                                                                                                                         |
| Jugular vein                  | Lymphatic contamination can be a concern with most locations of phlebotomy in chelonians; however, jugular considered less likely                                                                                                                                                                                                                                                                                       |
|                               | Right vein often larger than left; runs level with tympanum to base of neck with head extended; may require sedation                                                                                                                                                                                                                                                                                                    |
| Subcarapacial vein and plexus | The sinus accessed with patient’s head either extended or retracted; depending on conformation of carapace, needle may be bent up to 60° and positioned in midline just caudal to skin insertion of dorsal aspect of neck and ventral aspect of cranial rim of carapace; needle is advanced in caudodorsal direction, with slight negative pressure; can cause significant internal hemorrhage or paresis in some cases |
| Dorsal caudal vein            | Close to carapace, dorsal to dorsal aspect of vertebral body; lymphdilution common                                                                                                                                                                                                                                                                                                                                      |
| Crocodilians                  |                                                                                                                                                                                                                                                                                                                                                                                                                         |
| Ventral caudal vein           | Ventral aspect of vertebral body under center of middle scale; avoid hemipenes and anal sacs; this vein can also be approached laterally by inserting needle under lateral process of vertebral body aiming toward midline; ventral approach may in rare cases lead to tail necrosis/paresis                                                                                                                            |
| Supravertebral vein           | Position needle in dorsal midline, just caudal to occiput and perpendicular to skin surface, slowly advance needle with slight negative pressure; excessive penetration can cause spinal trauma                                                                                                                                                                                                                         |

<sup>a</sup> Generally recommended to collect only 0.7% body weight in healthy reptiles,

less in debilitated animals, so 0.7 mL total in 100 g animal.

TABLE 4-16 Treatment of Dystocia in Reptiles.<sup>a</sup> [10](#)·[30](#)·[294](#)

| Etiologies                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <ul style="list-style-type: none"><li>• Poor environmental conditions (improper thermal environment, lack of suitable nesting substrate, shallow nesting substrate; underground obstructions [e.g., roots or buried rocks], disturbance, lack of visual security, etc.)</li><li>• Social factors (e.g., competition, fighting, recent introduction of male)</li><li>• Dietary imbalances (e.g., calcium deficiency, hypovitaminosis A), malnutrition</li><li>• Endocrine imbalances</li><li>• Nutritional secondary hyperparathyroidism</li><li>• Uterine inertia</li><li>• Dehydration</li><li>• Renal disease</li><li>• Egg yolk coelomitis</li><li>• Cystic or cloacal calculi</li><li>• Infections (e.g., uterus)</li><li>• Anatomic anomalies of the reproductive tract or eggs</li><li>• Other (substrate ingestion, over-feeding, other illness, inadequate exercise)</li></ul> |
| Diagnosis                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
| <ul style="list-style-type: none"><li>• History and clinical signs (prolonged anorexia, lethargy, increased pacing/seeking, excavating nests without oviposition, straining to pass eggs, passage of a few eggs but not a full clutch, bloody discharge from cloaca)</li><li>• Knowledge of normal egg retention time or usual season for laying</li><li>• Physical examination (gentle palpation of inguinal fossa or caudal coelom; eggs may not be palpable)</li><li>• CBC (anemia, elevated or decreased WBCs)</li><li>• Plasma biochemical analysis (hyperproteinemia, elevated ALP activity, hyper or hypocalcemia)</li></ul>                                                                                                                                                                                                                                                    |

[ionized Ca <1 mmol/L])

- Coelomic effusion aspirate and cytology
- Radiography (tortoise eggs have a calcified outer shell and appear radiographically similar to avian eggs; turtles, lizards, and snakes generally have soft-shelled eggs with soft tissue density on radiographs)
- Ultrasound
- Coeloscopy—particularly to confirm coelomitis, salpingitis, or oviduct rupture; determine whether early surgical management is appropriate

**Treatment**

- If patient is stable, provide proper environmental conditions (appropriate thermal environment, humidity, nesting site, substrate material, substrate depth, and substrate moisture; minimal stimulus; isolation)
- Handle gently and infrequently
- Tepid (~29°C; ~85°F) water soak, 30-60 min q24h
- Rehydration—fluid therapy prn
- Alert, strong, stable, responsive females that are eating well will often oviposit without further therapy if given sufficient time
- Dextrose (SC, IV, ICe) may be of value in some cases
- Calcium (see [Table 4-8](#); only if hypocalcemic; low Ca<sup>++</sup> not generally a problem in snakes)
  - Ca glycerophosphate/Ca lactate (Calphosan, Glenwood) (5 mg each/mL): 5 mg/kg SC, IM
  - Ca gluconate: 100-200 mg/kg SC, IM
- Oxytocin<sup>b</sup> (see [Table 4-7](#))
  - Generally administer 1 hr after Ca<sup>++</sup> injection
  - 1-10 U/kg IM, ICe in lizards and snakes (results are variable); 2-20 U/kg IM, ICe for chelonians; may be repeated in 1 hr
- Arginine vasotocin<sup>c</sup> (Sigma Chemical) (alternative to oxytocin) (see [Table 4-7](#))
  - 0.01-1 µg/kg IV (preferred), ICe
- Dinoprostone gel (Prepodil, Upjohn) 0.9 mg/kg intracloacally followed 20 min later by prostaglandin F<sub>2α</sub> (Lutalyse, Upjohn) 0.6 mg/kg IM<sup>229</sup>

- Propranolol 1 mg/kg followed by prostaglandin F<sub>2α</sub> 0.025 mg/kg<sup>d</sup>
- Lubricate cloaca with water soluble gel
- Manual massage may be useful in some situations
- Salpingotomy may be required if declining clinical condition (i.e., anorexia, dehydration, lethargy)

<sup>a</sup> Although most reptiles are oviparous, some, including garter snakes, water snakes, boas (not pythons), vipers, Jackson’s chameleons, horned lizards, and Solomon Island prehensile-tailed skinks are viviparous.

<sup>b</sup> Use only if *no* evidence of obstructive dystocia or broken eggs.

<sup>c</sup> Appears to be more effective than oxytocin in many reptiles, but it is not commercially available for use in animals.

<sup>d</sup> Effective in healthy *Sceloporus* sp, did not induce oviposition in iguanas; may be effective in chelonians.

TABLE 4-17 Treatment of Metabolic Bone Diseases in Reptiles.<sup>156</sup>

| Etiology                                                                                                                                                                                                                                                                                                                       |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <ul style="list-style-type: none"> <li>• Improper Ca:P ratio; lack of dietary Ca</li> <li>• Lack of vitamin D<sub>3</sub></li> <li>• Lack of UVA and UVB light spectrum</li> <li>• Renal disease</li> <li>• Other: low ambient temperature, protein deficiency, small intestinal disease, parathyroid disease, etc.</li> </ul> |
| Clinical Signs                                                                                                                                                                                                                                                                                                                 |
| <ul style="list-style-type: none"> <li>• Lethargy, reluctance to move</li> <li>• Poor appetite or anorexia</li> <li>• Weight loss or poor weight gain</li> </ul>                                                                                                                                                               |

- Softening of the mandible; shortened/rounded mandible and maxilla; symmetrical swelling of the mandible (fibrous osteodystrophy)
- Fibrous osteodystrophy of the long bones of the legs
- Difficulty in lifting body off ground when walking
- Pathologic fractures
- Ataxia, paresis, or paralysis of the rear legs due to collapsed vertebrae or vertebral luxation
- Osteoporosis
- Hypocalcemic muscle fasciculations and seizures
- Soft shell in chelonians
- Constipation

**Diagnosis**

- Dietary and environmental history
- Clinical signs
- Physical examination
- Radiography
- Serum Ca:P ratio; usually inverse (1:2+) with renal etiology
- Uric acid levels
- Ionized calcium levels
- Calcidiol (25-hydroxyvitamin D) levels (Michigan State University)
- UV meter readings of enclosure
- Dual energy x-ray absorptiometry (DEXA) scan
- Determination of glomerular filtration rate
- Renal nuclear medicine
- Renal biopsy

**Treatment**

- Provide species-correct environmental temperature ranges for day and night
- Correct diet as needed; usually changing to improve calcium:phosphorus ratio
- Use species-appropriate UVA/UVB lighting arrangement
- Use either fluorescent or mercury vapor bulbs
- Provide areas to hide, as corneal and skin burns can occur
- In general:
  - Desert-dwelling diurnal lizards/chelonians, high UVB levels (10% or full unfiltered sun, 8 hr)
  - Diurnal arboreal lizards/semiaquatic basking chelonians, moderate levels of UVB (5%, 8 hr)
  - Diurnal terrestrial lizards/chelonians from forested environment, low levels of UVB (5%, 4 hr)
  - Nocturnal lizards, low levels of UVB (2%, 4 hr)
  - Snakes seem to get adequate levels of calcium/cholecalciferol from ingestion of whole vertebrate prey (or earthworms); exceptions are: diamond and green tree pythons, indigo snakes, some aquatic species, rough/smooth green snakes, other arboreal, diurnal snakes
    - Albino (amelanistic), hypomelanistic, snow, blizzard, pastel, tangerine, lavender, yellow, pied, anerythristic, leucistic, xanthochromistic, or any other genetic mutant with less than normal levels of melanin are more susceptible to UV light burns of the eyes and dorsal skin, so lower levels of UV supplementation (if any) should be provided
- Force-feeding (following rehydration) (see [Table 4-13](#))
  - Use species-appropriate diet, especially useful for immature animals as maintenance until improving and closer to adult size, esophageal feeding tube usually needed for chelonians to avoid beak fractures
- Ca supplementation options (see [Table 4-8](#))—best to use human products
  - Calcium carbonate (400 mg calcium/g product)
  - Calcium citrate (210 mg calcium/g product)
  - Calcium phosphate
- Maintain hydration
  - Fluid therapy, as needed
  - Soak in warm water (shallow) for 10-20 min q12-24h to encourage drinking and defecation (caution: head may need to be supported; do not leave unattended)
- Vitamin D<sub>3</sub> (see [Table 4-8](#))
  - Best source is UVA/UVB exposure from sun or appropriate lamp
- Calcitonin to prevent further transfer of Ca from bone to blood (hormone therapies should always be performed cautiously)

|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <ul style="list-style-type: none"> <li>• 50 U/kg IM q7d × 2 treatments</li> <li>• Ca supplementation should be given prior to and during calcitonin therapy</li> <li>• Serum Ca should be within normal limits prior to calcitonin therapy; if Ca levels cannot be determined, administer calcium 7 days prior to calcitonin</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
| <ul style="list-style-type: none"> <li>• Gut-load invertebrates (crickets, mealworms, superworms, cockroaches) on high calcium diet (high calcium leafy greens, Mazuri Hi-Ca Cricket Diet) for several days before feeding to insectivores</li> <li>• Feed high calcium invertebrates such as phoenix worms, snails, and earthworms when appropriate for diet in insectivores</li> <li>• Dusting invertebrates may be beneficial; but they often remove dust quickly, can make unpalatable, and be careful with dusts containing vitamins, avoid those with phosphorus</li> <li>• Feed only leafy greens and other high calcium plants for herbivores, minimizing thicker vegetables and avoiding most fruits</li> <li>• In mammals, condition considered painful, appropriate analgesics may be warranted</li> <li>• Both short-term and long-term prognosis is often guarded at best</li> <li>• Other             <ul style="list-style-type: none"> <li>• Handle gently</li> <li>• Remove climbing branches to prevent injuries</li> </ul> </li> </ul> |

TABLE 4-18 Selected Sources of Diets and Other Commercial Products for Reptiles.<sup>a,b</sup>



## Foods and Supplements

|                           |              |                                                                            |  |
|---------------------------|--------------|----------------------------------------------------------------------------|--|
| Fluker Farms              | 800-735-8537 | <a href="http://www.flukerfarms.com">www.flukerfarms.com</a>               |  |
| Drs Foster & Smith        | 800-443-1160 | <a href="http://www.drsfostersmith.com">www.drsfostersmith.com</a>         |  |
| Kaytee                    | 800-529-8331 | <a href="http://www.kaytee.com">www.kaytee.com</a>                         |  |
| Mazuri                    | 800-227-8941 | <a href="http://www.mazuri.com">www.mazuri.com</a>                         |  |
| Oxbow Animal Health       | 800-249-0366 | <a href="http://www.oxbowanimalhealth.com">www.oxbowanimalhealth.com</a>   |  |
| Pretty Pets               | 800-356-5020 | <a href="http://www.prettybird.com">www.prettybird.com</a>                 |  |
| Reliable Protein Products | 480-361-3940 | <a href="http://www.zoofood.com">www.zoofood.com</a>                       |  |
| Repashy Superfoods        | 855-737-2749 | <a href="http://www.store.repashy.com">www.store.repashy.com</a>           |  |
| Rep-Cal                   | 800-406-6446 | <a href="http://www.repcal.com">www.repcal.com</a>                         |  |
| San Francisco Bay Brand   | 510-792-7200 | <a href="http://sfbb.com">http://sfbb.com</a>                              |  |
| Sticky Tongue Farms       | 951-244-3434 | <a href="http://www.stickytonguelfarms.com">www.stickytonguelfarms.com</a> |  |
| Tetra Fauna               | 800-423-6458 | <a href="http://www.tetra-fish.com">www.tetra-fish.com</a>                 |  |
| T-Rex Products            | 800-991-8739 | <a href="http://www.t-rexproducts.com">www.t-rexproducts.com</a>           |  |
| Zoo Med Laboratories      | 888-496-6633 | <a href="http://www.zoomed.com">www.zoomed.com</a>                         |  |
| ZuPreem                   | 800-345-4767 | <a href="http://www.zupreem.com">www.zupreem.com</a>                       |  |

## Live/Frozen Foods for Carnivores

|                        |              |                                                                            |                                                                    |
|------------------------|--------------|----------------------------------------------------------------------------|--------------------------------------------------------------------|
| American Rodent Supply | 317-899-1599 | <a href="http://www.americanrodent.com">www.americanrodent.com</a>         | Frozen mice, rats                                                  |
| Big Cheese Rodents     | 800-887-0921 | <a href="http://www.bigcheeserodents.com">www.bigcheeserodents.com</a>     | Frozen mice, rats                                                  |
| Carolina Mouse Farm    | 864-944-6192 | —                                                                          | Frozen mice, rats                                                  |
| The Gourmet Rodent     | 352-472-9189 | <a href="http://www.gourmetrodent.com">www.gourmetrodent.com</a>           | Frozen mice, rats, rabbits, chicks                                 |
| Hoosier Mouse Supply   | 317-831-1219 | <a href="http://www.hoosiermousesupply.com">www.hoosiermousesupply.com</a> | Live (local) and frozen mice, rats                                 |
| Komodo Reptiles        | 914-788-8722 | <a href="http://www.komodoreptiles.com">www.komodoreptiles.com</a>         | Live (local) and frozen mice, rats                                 |
| Mouse Factory          | 800-720-0076 | <a href="http://www.themousefactory.com">www.themousefactory.com</a>       | Live and frozen mice, rats                                         |
| Perfect Pets Inc       | 800-366-8794 | <a href="http://www.perfectpet.net">www.perfectpet.net</a>                 | Frozen mice, rats, hamsters, gerbils, guinea pigs, rabbits, chicks |
| Rodent Pro             | 812-867-7598 | <a href="http://www.rodentpro.com">www.rodentpro.com</a>                   | Frozen mice, rats, rabbits, guinea pigs, chicks, quail             |

## Live Foods for Insectivores

|                         |              |                                                                                        |                                                                             |
|-------------------------|--------------|----------------------------------------------------------------------------------------|-----------------------------------------------------------------------------|
| Arbico Organics         | 800-827-2847 | <a href="http://www.arbico-organics.com">www.arbico-organics.com</a>                   | Crickets, fly pupae, mealworms, waxworms, superworms                        |
| Bassett's Cricket Ranch | 800-634-2445 | <a href="http://www.bccricket.com">www.bccricket.com</a>                               | Crickets, mealworms                                                         |
| The Drosophila Co       | 800-545-2303 | <a href="http://www.jtresser.com/drosophila.html">www.jtresser.com/drosophila.html</a> | Fruit flies                                                                 |
| Fluker Farms            | 800-735-8537 | <a href="http://www.flukerfarms.com">www.flukerfarms.com</a>                           | Crickets, mealworms, fruit flies, hissing cockroaches                       |
| Ghann's Cricket Farm    | 800-476-2248 | <a href="http://www.ghann.com">www.ghann.com</a>                                       | Crickets, soldier fly larvae                                                |
| Grubco                  | 800-222-3563 | <a href="http://www.grubco.com">www.grubco.com</a>                                     | Crickets, superworms, mealworms, fly larvae                                 |
| Knutson's               | 800-248-9318 | <a href="http://www.knutsonlivebait.com">www.knutsonlivebait.com</a>                   | Night crawlers, crickets, mealworms                                         |
| Komodo Reptiles         | 914-788-8722 | <a href="http://www.komodoreptiles.com">www.komodoreptiles.com</a>                     | Crickets, superworms, goliath worms, fruit flies, mealworms, night-crawlers |
| Millbrook Cricket Farm  | 800-654-3506 | <a href="http://www.millbrookcrickets.com">www.millbrookcrickets.com</a>               | Crickets, mealworms, superworms                                             |
| Mulberry Farms          | 760-731-6088 | <a href="http://www.mulberryfarms.com">www.mulberryfarms.com</a>                       | Silkworm larvae                                                             |
| The Phoenix Worm Store  | —            | <a href="http://www.phoenixworm.com">www.phoenixworm.com</a>                           | Soldier fly larvae                                                          |
| Rainbow Mealworms       | 800-777-9676 | <a href="http://www.rainbowmealworms.net">www.rainbowmealworms.net</a>                 | Crickets, mealworms, cockroaches                                            |
| Russell's Cricket Farm  | 234-738-3663 | <a href="http://www.livecrickets.com">www.livecrickets.com</a>                         | Crickets, mealworms, superworms                                             |

*Continued*

|                        |              |                                                                          |                                                      |
|------------------------|--------------|--------------------------------------------------------------------------|------------------------------------------------------|
| Sunshine Mealworms     | 800-322-1100 | <a href="http://www.sunshinemealworms.com">www.sunshinemealworms.com</a> | Mealworms, crickets, superworms                      |
| Top Hat Cricket Farm   | 800-638-2555 | <a href="http://www.tophatcrickets.com">www.tophatcrickets.com</a>       | Crickets, mealworms, superworms, hornworms, waxworms |
| Topline Whlse Dist Co. | 888-922-0464 | <a href="http://www.topline-2000.com">www.topline-2000.com</a>           | Nightcrawlers, redworms, hissing cockroaches         |

## Lights

|                         |              |                                                                        |                                                              |
|-------------------------|--------------|------------------------------------------------------------------------|--------------------------------------------------------------|
| Duro-Test Lighting      | 800-289-3876 | —                                                                      | Vita-Lite fluorescent                                        |
| Fluker Farms            | 800-735-8537 | <a href="http://www.flukerfarms.com">www.flukerfarms.com</a>           | Incandescent, heat                                           |
| General Electric        | 800-435-4448 | <a href="http://www.gelighting.com">www.gelighting.com</a>             | Incandescent, heat                                           |
| Hikari Sales USA        | 800-621-5619 | <a href="http://www.hikariusa.com">www.hikariusa.com</a>               | UVB fluorescent                                              |
| Mac Industries, Inc     | 252-241-4584 | <a href="http://www.reptileuv.com">www.reptileuv.com</a>               | Mega-ray UVB                                                 |
| Philips                 | 800-555-0050 | <a href="http://www.lighting.philips.com">www.lighting.philips.com</a> | Incandescent, heat                                           |
| Sylvania                | 978-777-1900 | <a href="http://www.sylvania.com">www.sylvania.com</a>                 | 350BL blacklights                                            |
| T-Rex Products          | 800-991-8739 | <a href="http://www.t-rexproducts.com">www.t-rexproducts.com</a>       | Mercury vapor UVB,<br>incandescent, heat                     |
| Zilla                   | 888-255-4527 | <a href="http://www.zilla-rules.com">www.zilla-rules.com</a>           | Incandescent, heat, UVB<br>fluorescent                       |
| Zoo Med<br>Laboratories | 888-496-6633 | <a href="http://www.zoomed.com">www.zoomed.com</a>                     | Incandescent, heat,<br>mercury vapor UVB,<br>fluorescent UVB |

## Heating Devices

|                         |              |                                                                  |                                               |
|-------------------------|--------------|------------------------------------------------------------------|-----------------------------------------------|
| Avitec                  | 800-646-2473 | <a href="http://www.avitec.com">www.avitec.com</a>               | Conical ceramic heat<br>emitters, thermostats |
| The Bean Farm           | 877-708-5882 | <a href="http://www.beanfarm.com">www.beanfarm.com</a>           | Heat tape, heat pads                          |
| Big Apple Pet<br>Supply | 800-922-7753 | <a href="http://www.bigappleherp.com">www.bigappleherp.com</a>   | Thermostats                                   |
| Fluker Farms            | 800-735-8537 | <a href="http://www.flukerfarms.com">www.flukerfarms.com</a>     | Under-cage heat pads                          |
| Helix Controls          | 760-726-4464 | <a href="http://www.helixcontrols.com">www.helixcontrols.com</a> | Thermostats, heat tape,<br>heat panels        |
| LLL Reptile             | 888-547-3784 | <a href="http://lllreptile.com">http://lllreptile.com</a>        | Pearlco conical ceramic<br>heat emitters      |

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|                         |              |                                                              |                                                    |
|-------------------------|--------------|--------------------------------------------------------------|----------------------------------------------------|
| Zilla                   | 888-255-4527 | <a href="http://www.zilla-rules.com">www.zilla-rules.com</a> | Conical ceramic heat<br>emitters, thermostats      |
| Zoo Med<br>Laboratories | 888-496-6633 | <a href="http://www.zoomed.com">www.zoomed.com</a>           | Thermostats, rheostats,<br>heat pads, tape, cables |

## Humidity Devices

|                         |              |                                                              |                                                                                       |
|-------------------------|--------------|--------------------------------------------------------------|---------------------------------------------------------------------------------------|
| Exo Terra (Hagen)       | 800-724-2436 | <a href="http://www.exo-terra.com">www.exo-terra.com</a>     | Ultrasonic fogger,<br>Monsoon rainfall                                                |
| Humidifirst             | 561-752-1936 | <a href="http://www.humidifirst.com">www.humidifirst.com</a> | Mist Pac ultrasonic<br>humidifiers                                                    |
| Zoo Med<br>Laboratories | 888-496-6633 | <a href="http://www.zoomed.com">www.zoomed.com</a>           | Ultrasonic fogger, Repti<br>fogger, Habba mist,<br>Hygro-Therm humidity<br>controller |



## Environmental Sensing and Monitoring Devices

|                      |              |                                                              |                                                  |
|----------------------|--------------|--------------------------------------------------------------|--------------------------------------------------|
| Exo Terra (Hagen)    | 800-724-2436 | <a href="http://www.exo-terra.com">www.exo-terra.com</a>     | Remote digital thermometers, hygrometers         |
| FLIR                 | 866-477-3687 | <a href="http://www.flir.com">www.flir.com</a>               | Infrared thermography                            |
| Onset Computer Corp. | 800-564-4377 | <a href="http://www.onsetcomp.com">www.onsetcomp.com</a>     | HOBO data loggers                                |
| Pro Exotics          | 303-347-0500 | <a href="http://www.proexotics.com">www.proexotics.com</a>   | Digital infrared thermometer                     |
| Raytek               | 800-227-8074 | <a href="http://www.raytek.com">www.raytek.com</a>           | Digital infrared thermometer                     |
| Solartech            | 800-798-3311 | <a href="http://www.solarmeter.com">www.solarmeter.com</a>   | Solarmeter 6.2 UVB meter                         |
| Zilla                | 888-255-4527 | <a href="http://www.zilla-rules.com">www.zilla-rules.com</a> | Digital infrared thermometer                     |
| Zoo Med Laboratories | 888-496-6633 | <a href="http://www.zoomed.com">www.zoomed.com</a>           | Hygro-Therm humidity/heat monitor and controller |

\*Many pet stores sell live and frozen food for reptiles, and many of the products listed.

\*Numerous sources of information were used to compile this table, particularly Internet sources.

## References

1. Adnyana W, Ladds PW, Blair D. Efficacy of praziquantel in the treatment of green sea turtles with spontaneous infection of cardiovascular flukes. *Aust Vet J*. 1997;75:405–407.
2. Alleman AR, Jacobson ER, Raskin RE. Morphologic and cytochemical characteristics of blood cells from the desert tortoise (*Gopherus agassizii*). *Proc Annu Conf Assoc Rept Amph Vet*. 1996:51–55.
3. Allen DG, Pringle JK, Smith D. Handbook of Veterinary Drugs. Philadelphia: JB Lippincott Co; 1993:534–567.
4. American Veterinary Medical Association. AVMA guidelines on euthanasia. Available at [www.avma.org/issues/animal\\_welfare/euthanasia.pdf](http://www.avma.org/issues/animal_welfare/euthanasia.pdf), May 6, 2011. Accessed
5. Anderson NL, Wack RF. Basic husbandry and medicine of pet reptiles. In: Birchard SJ, Sherding RG. *Saunders Manual of Small Animal Practice*. 2nd ed. Philadelphia: WB Saunders Co; 2000:1539–1567.

6. Anderson NL, Wack RF, Calloway L. Cardiopulmonary effects and efficacy of propofol as an anesthetic agent in brown tree snakes, *Boiga irregularis*. *Bull Assoc Rept Amph Vet*. 1999;9:9–15.
7. Antinoff N, Bauck L, Boyer TH, et al. *Exotic Animal Formulary*, 2nd ed. Lakewood, CO: AAHA Press; 1999.
8. Baker BB, Sladky KK, Johnson SM. Evaluation of the analgesic effects of oral and subcutaneous tramadol administration in red-eared slider turtles. *J Am Vet Med Assoc*. 2011;238:220–227.
9. Barrie MT. Chameleon medicine. In: Fowler ME, Miller RE. *Zoo and Wild Animal Medicine: Current Therapy 4*. Philadelphia: WB Saunders Co; 1999:200–205.
10. Barten SL. The medical care of iguanas and other common pet lizards. *Vet Clin North Am Small Anim Pract*. 1993;23:1213–1249.
11. Beck K, Loomis M, Lewbart G, et al. Preliminary comparison of plasma concentrations of gentamicin injected into the cranial and caudal limb musculature of the eastern box turtle (*Terrapene carolina carolina*). *J Zoo Wildl Med*. 1995;26:265–268.
12. Bennett RA. A review of anesthesia and chemical restraint in reptiles. *J Zoo Wildl Med*. 1991;22:282–303.
13. Bennett RA. Anesthesia. In: Mader DR, ed. *Reptile Medicine and Surgery*. Philadelphia: WB Saunders Co; 1996:241–247.
14. Bennett RA. Clinical, diagnostic, and therapeutic techniques. *Proc Annu Conf Assoc Rept Amph Vet*; 1998:35–40.
15. Bennett RA. Management of common reptile emergencies. *Proc Annu Conf Assoc Rept Amph Vet*. 1998:67–72.
16. Bennett RA. Reptile anesthesia. *Semin Avian Exotic Pet Med*. 1998;7:30–40.
17. Bennett RA. Personal communication; 2002.

18. Bennett RA, Divers SJ, Schumacher J, et al. Roundtable. anesthesia. *Bull Assoc Rept Amph Vet.* 1999;9:20–27.
19. Bennett RA, Schumacher J, Hedjazi-Haring K, et al. Cardiopulmonary and anesthetic effects of propofol administered intraosseously to green iguanas. *J Am Vet Med Assoc.* 1998;212:93–98.
20. Benson KG, Tell LA, Young LA, et al. Pharmacokinetics of ceftiofur sodium after intramuscular or subcutaneous administration in green iguanas (*Iguana iguana*). *Am J Vet Res.* 2003;64:1278–1282.
21. Bernard JB, Oftedal OT, Citino SB, et al. The response of vitamin D-deficient green iguanas (*Iguana iguana*) to artificial ultraviolet light. *Proc Annu Conf Am Assoc Zoo Vet.* 1991:147–150.
22. Bicknese E, Pessier A, Boedeker N. Successful treatment of fungal osteomyelitis in a Parson's chameleon (*Calumma parsonii*) using surgical and anti-fungal treatments. *Proc Annu Conf Assoc Rept Amph Vet;* 2008:86.
23. Bienzle D, Boyd CJ. Sedative effects of ketamine and midazolam in snapping turtles. *J Zoo Wildl Med.* 1992;23:201–204.
24. Bodri MS, Hrubá SJ. Safety of milbemycin (A3-A4 oxime) in chelonians. *Proc Joint Conf Am Assoc Zoo Vet/Am Assoc Wildl Vet.* 1992:156–157.
25. Bodri MS, Rambo TM, Wagner RA, et al. Pharmacokinetics of metronidazole administered as a single oral bolus to red rat snakes, *Elaphe guttata*. *J Herp Med Surg.* 2006;16:15–19.
26. Bogoslavsky B. The use of ponazuril to treat coccidiosis in eight inland bearded dragons (*Pogona vitticeps*). *Proc Annu Conf Assoc Rept Amph Vet;* 2007:8–9.
27. Boyer TH. Clinical anesthesia of reptiles. *Bull Assoc Rept Amph Vet.* 1992;2:10–13.
28. Boyer TH. Common problems of box turtles (*Terrapene* spp) in captivity. *Bull Assoc Rept Amph Vet.* 1992;2:9–14.

29. Boyer TH. Emergency care of reptiles. *Semin Avian Exotic Pet Med*. 1994;3:210–216.
30. Boyer TH. Emergency care of reptiles. *Vet Clin North Am Exotic Anim Pract*. 1998;1:191–206.
31. Boyer TH. Essentials of Reptiles. A Guide for Practitioners. Lakewood, CO: AAHA Press; 1998:1–253.
32. Burns RB, McMahan W. Euthanasia methods for ectothermic vertebrates. In: Bonagura JD, ed. *Kirk's Current Veterinary Therapy XII: Small Animal Practice*. Philadelphia: WB Saunders Co; 1995:1379–1381.
33. Bush M, Smeller JM, Charache PN, et al. Preliminary study of antibiotics in snakes. *Proc Annu Conf Am Assoc Zoo Vet*; 1976:50–54.
34. Bush M, Smeller JM, Charache P, et al. Biological half-life of gentamicin in gopher snakes. *Am J Vet Res*. 1978;39:171–173.
35. Caligiuri R, Kollias GV, Jacobson E, et al. The effects of ambient temperature on amikacin pharmacokinetics in gopher tortoises. *J Vet Pharm Therapeut*. 1990;13:287–291.
36. Calvert I. Nutritional problems. In: Girling SJ, Raiti P. *BSAVA Manual of Reptiles*. 2nd ed. Quedgeley, Gloucester: British Small Animal Veterinary Association; 2004:289–308.
37. Carpenter JW. Radiographic imaging of reptiles. *Proc North Am Vet Conf*; 1998:873–875.
38. Carpenter JW. Personal observation; 2011.
39. Casares M, Enders F. Enrofloxacin side effects in a Galapagos tortoise (*Geochelone elephantopus nigra*). *Proc Annu Conf Am Assoc Zoo Vet*; 1996:446–448.
40. Centini R, Klaphake E. Hematologic values and cytology in a population of captive jungle carpet pythons, *Morelia spilota cheynei*. *Proc Annu Conf Assoc*

Rept Amph Vet; 2002:107–111.

41. Chiodini RJ, Sundberg JP. Blood chemical values of the common boa constrictor (*Constrictor constrictor*). *Am J Vet Res*. 1982;43:1701–1702.
42. Chittick EJ, Stamper MA, Beasley JF, et al. Medetomidine, ketamine, and sevoflurane for anesthesia of injured loggerhead sea turtles. 13 cases (1996-2000). *J Am Vet Med Assoc*. 2002;221:1019–1025.
43. Chitty JR. Use of a novel disinfectant agent in reptile respiratory disease. *Proc Annu Conf Assoc Rept Amph Vet*; 2003:65–67.
44. Christopher MM, Berry KH, Wallis IR, et al. Reference intervals and physiologic alterations in hematologic and biochemical values of free-ranging desert tortoises in the Mojave Desert. *J Wildl Dis*. 1999;35:212–238.
45. Clark CH, Rogers ED, Milton JL. Plasma concentrations of chloramphenicol in snakes. *Am J Vet Res*. 1985;46:2654–2657.
46. Clyde VL, Cardeilhac PT, Jacobson ER. Chemical restraint of American alligators (*Alligator mississippiensis*) with atracurium or tiletamine-zolazepam. *J Zoo Wildl Med*. 1994;25:525–530.
47. Coke RL, Tristan TE. Cryptosporidium infection in a colony of leopard geckos, *Eublepharis macularius*. *Proc Annu Conf Assoc Rept Amph Vet*; 1998:157–163.
48. Coke RL, Hunter RP, Isaza R, et al. Pharmacokinetics and tissue concentrations of azithromycin in ball pythons (*Python regius*). *Am J Vet Res*. 2003;64:225–228.
49. Coke RL, Isaza R, Koch DE, et al. Preliminary single-dose pharmacokinetics of marbofloxacin in ball pythons (*Python regius*). *J Zoo Wildl Med*. 2006;37:6–10.
50. Cooper JE. Anaesthesia of exotic animals. *Anim Technol*. 1984;35:13–20.
51. Cranfield MR, Graczyk TK. Cryptosporidiosis. In: Mader DR, ed. *Reptile*



*Medicine and Surgery*. 2nd ed. St. Louis: Saunders/Elsevier; 2006:756–762.

52. Crawshaw GJ, Holz P. Comparison of plasma biochemical values in blood and blood-lymph mixtures from red-eared sliders, *Trachemys scripta elegans*. *Bull Assoc Rept Amph Vet*. 1996;6:7–9.

53. Cunningham AA, Gill C. Management in captivity. In: Benyon PH, Lawton MPC, Cooper JE. *Manual of Reptiles*. Ames: Iowa State University Press; 1992:14–31.

54. Dallwig R. Allopurinol. *J Exotic Pet Med*. 2010;19:255–257.

55. DeNardo DF, Helminski G. Birth control in lizards? Therapeutic inhibition of reproduction. *Proc Annu Conf Assoc Rept Amph Vet*; 2000:65–66.

56. Dennis PM, Heard DJ. Cardiopulmonary effects of a medetomidine-ketamine combination administered intravenously in gopher tortoises. *J Am Vet Med Assoc*. 2002;220:1516–1519.

57. Dennis PM, Bennett RA, Harr KE, et al. Plasma concentration of ionized calcium in healthy iguanas. *J Am Vet Med Assoc*. 2001;219:326–328.

58. Dickinson VM, Jarchow JL, Trueblood MH. Hematology and plasma biochemistry reference range values for free-ranging desert tortoises in Arizona. *J Wildl Dis*. 2002;38:143–153.

59. Diethelm G, Stein G. Hematologic and blood chemistry values in reptiles. In: Mader DR, ed. *Reptile Medicine and Surgery*. 2nd ed. St. Louis: Saunders/Elsevier; 2006:1103–1118.

60. Divers SJ. Constipation in snakes with particular reference to surgical correction in a Burmese python (*Python molurus bivittatus*). *Proc Annu Conf Assoc Rept Amph Vet*; 1996:67–69.

61. Divers SJ. Medical and surgical treatment of pre-ovulatory ova stasis and post-ovulatory egg stasis in oviparous lizards. *Proc Annu Conf Assoc Rept Amph Vet*; 1996:119–123.

62. Divers SJ. The use of propofol in reptile anesthesia. *Proc Annu Conf Assoc Rept Amph Vet*; 1996:57–59.
63. Divers SJ. Clinician's approach to renal disease in lizards. *Proc Annu Conf Assoc Rept Amph Vet*; 1997:5–11.
64. Diver SJ. Empirical doses of antimicrobial drugs commonly used in reptiles. *Exotic DVM*. 1998;1:23.
65. Divers SJ. Anesthetics in reptiles. *Exotic DVM*. 1999;1(3):7–8.
66. Divers SJ, Redmayne G, Aves EK. Haematological and biochemical values of 10 green iguanas (*Iguana iguana*). *Vet Rec*. 1996;138:203–205.
67. Divers SJ, Papich MG, McBride M, et al. Pharmacokinetics of meloxicam following intravenous and oral administration in green iguanas (*Iguana iguana*). *Am J Vet Res*. 2010;71:1277–1283.
68. Doneley B. Caring for the bearded dragon. *Proc North Am Vet Conf*; 2006:1607–1611.
69. Donoghue S. Nutrition. In: Mader DR, ed. *Reptile Medicine and Surgery*. 2nd ed. St. Louis: Saunders/Elsevier; 2006:251–298.
70. Drew ML. Hypercalcemia and hyperphosphatemia in indigo snakes (*Drymarchon corais*) and serum biochemical reference values. *J Zoo Wildl Med*. 1994;25:48–52.
71. Dundee HA, Rossman DA. The Amphibians and Reptiles of Louisiana. Baton Rouge: Louisiana State University Press; 1989:270–272.
72. Ellman MM. Hematology and plasma chemistry of the inland bearded dragon, *Pogona vitticeps*. *Bull Assoc Rept Amph Vet*. 1997;7:10–12.
73. Farnsworth RJ, Brannian RE, Fletcher KC, et al. A vitamin E-selenium responsive condition in a green iguana. *J Zoo Anim Med*. 1986;17:42–43.
74. Faulkner JE, Archambault A. Anesthesia and surgery in the green iguana.

*Semin Avian Exotic Pet Med.* 1993;2:103–108.

75. Fitzgerald KT, Vera R. Acariasis. In: Mader DR, ed. *Reptile Medicine and Surgery*. 2nd ed. St. Louis: Saunders/Elsevier; 2006:720–738.

76. Flach EJ, Riley J, Mutlow AG, et al. Pentastomiasis in Bosc's monitor lizards (*Varanus exanthematicus*) caused by an undescribed *Sambonia* species. *J Zoo Wildl Med.* 2000;31:91–95.

77. Fleming G. Clinical technique. chelonian shell repair. *J Exotic Pet Med.* 2008;17:246–258.

78. Fleming GJ. Capture and chemical immobilization of the Nile crocodile (*Crocodylus niloticus*) in South Africa. *Proc Annu Conf Assoc Rept Amph Vet*; 1996:63–66.

79. Fleming GJ. Crocodilian anesthesia. *Vet Clin North Am Exotic Anim Pract.* 2001;4:119–145.

80. Flint M, Morton JM, Limpus CJ, et al. Development and application of biochemical and haematological reference intervals to identify unhealthy green sea turtles (*Chelonia mydas*). *Vet J.* 2010;185:299–304.

81. Franco KH, Hoover JP. Levothyroxine as a treatment for presumed hypothyroidism in an adult male African spurred tortoise (*Centrochelys* (formerly *Geochelone*) *sulcata*). *J Herp Med Surg*. 2009;19:42–44.
82. Fraser MA, Girling SJ. Dermatology. In: Girling SJ, Raiti P. *BSAVA Manual of Reptiles*. 2nd ed. Quedgeley, Gloucester: British Small Animal Veterinary Association; 2004:184–198.
83. Frye FL. Reptile Care. An Atlas of Diseases and Treatments. Neptune City, NJ: TFH Publications; 1991:1–637.
84. Frye FL. *Reptile Clinician's Handbook*. Malabar, FL: Krieger Publishing; 1994.
85. Fudge AM. Laboratory reference ranges for selected avian, mammalian, and reptilian species. In: Fudge AM, ed. *Laboratory Medicine: Avian and Exotic Pets*. Philadelphia: WB Saunders Co; 2000:375–400.
86. Funk RS. A formulary for lizards, snakes, and crocodilians. *Vet Clin North Am Exotic Anim Pract*. 2000;3:333–358.
87. Funk RS, Diethelm G. Reptile formulary. In: Mader DR, ed. *Reptile Medicine and Surgery*. 2nd ed. St. Louis: Saunders/Elsevier; 2006:1119–1139.
88. Gaio C, Rossi T, Villa R, et al. Pharmacokinetics of acyclovir after a single oral administration in marginated tortoises, *Testudo marginata*. *J Herp Med Surg*. 2007;17:8–11.
89. Gamble KC. Plasma fentanyl concentrations achieved after transdermal fentanyl patch application in prehensile-tailed skinks, *Corucia zebrata*. *J Herp Med Surg*. 2008;18:81–85.
90. Gamble KC, Alvarado TP, Bennett CL. Itraconazole plasma and tissue concentrations in the spiny lizard (*Sceloporus* sp.) following once-daily dosing. *J Zoo Wildl Med*. 1997;28:89–93.
91. Gaumer A, Goodnight CJ. Some aspects of the hematology of turtles as related to their activity. *Am Midland Nat*. 1957;58:332–340.

92. Gauvin J. Drug therapy in reptiles. *Semin Avian Exotic Pet Med*. 1993;2:48–59.
93. Georoff TA, Stacy NI, Newton AN, et al. Diagnosis and treatment of chronic T-lymphocytic leukemia in a green tree monitor (*Varanus prasinus*). *J Herp Med Surg*. 2009;19:106–114.
94. Giannetto S, Brianti E, Poglayen G, et al. Efficacy of oxfendazole and fenbendazole against tortoise (*Testudo hermanni*) oxyurids. *Parasitol Res*. 2007;100:1069–1073.
95. Gibbons PM. Critical care nutrition and fluid therapy in reptiles. Proc 15th Annu Intl Vet Emerg Crit Care Symp; 2009:91–94.
96. Gibbons PM. Personal observation; 2011.
97. Gibbons PM, Horton SJ, Brandl SR. Urinalysis in box turtles, *Terrapene* spp. Proc Annu Conf Assoc Rept Amph Vet; 2000:161–168.
98. Gillespie D. Reptiles. In: Birchard SJ, Sherding RG. *Saunders Manual of Small Animal Practice*. Philadelphia: WB Saunders Co; 1994:1390–1411.
99. Gimenez M, Saco Y, Pato R, et al. Plasma protein electrophoresis of *Trachemys scripta* and *Iguana iguana*. *Vet Clin Pathol*. 2010;39:227–235.
100. Girling SJ, Raiti P. *BSAVA Manual of Reptiles*, 2nd ed. Quedgeley, Gloucester: British Small Animal Veterinary Association; 2004.
101. Gottdenker NL, Jacobson ER. Effect of venipuncture sites on hematologic and clinical biochemical values in desert tortoises (*Gopherus agassizii*). *Am J Vet Res*. 1995;56:19–21.
102. Greenacre CB, Massi K, Schumacher JP, et al. Comparative antinociception of various opioids and non-steroidal anti-inflammatory medications versus saline in the bearded dragon (*Pogona vitticeps*) using electrostimulation. Proc Annu Conf Rept Amph Vet; 2008:87.
103. Groza A, Mederle N, Darabus G. Advocate-therapeutical solution in

parasitical infestation in frillneck lizard (*Chlamydosaurus kingii*) and bearded dragon (*Pogona vitticeps*). *Lucrari Stiintifice—Universitatea Stiinte Agricole Banatului Timisoara, Med Vet.* 2009;42:105–108.

104. Hackenbroich C, Failing K, Axt-Findt U, et al. Alphaxalone-alphadolone anesthesia in *Trachemys scripta elegans* and its influence on respiration, circulation and metabolism. *Proc 2nd Conf Euro Assoc Zoo Wildl Vet*; 1998:431–436.

105. Harkewicz KA. Dermatologic problems of reptiles. *Semin Avian Exotic Pet Med.* 2002;11:151–161.

106. Harless M, Morlock H. Turtles—Perspectives and Research. New York: John Wiley & Sons; 1979:356–366.

107. Harms CA, Lewbart GA, Beasley J. Medical management of mixed nocardial and unidentified fungal osteomyelitis in a Kemp's Ridley sea turtle, *Lepidochelys kempii*. *J Herp Med Surg.* 2002;12:21–26.

108. Harr KE, Alleman AR, Dennis PM, et al. Morphologic and cytochemical characteristics of blood cells and hematologic and plasma biochemical reference ranges in green iguanas. *J Am Vet Med Assoc.* 2001;218:915–921.

109. Heard DJ. Principles and techniques of anesthesia and analgesia for exotic practice. *Vet Clin North Am Small Anim Pract.* 1993;23:1301–1327.

110. Heard DJ. Advances in reptile anesthesia and medicine. *Proc Annu Conf Assoc Avian Vet/Avian Speciality Advanced Prog/Small Mam Rept Prog*; 1998:113–119.

111. Heard DJ. Advances in reptile anesthesia. *Proc North Am Vet Conf*; 1999:770.

112. Heard D, Harr K, Wellehan J. Diagnostic sampling and laboratory tests. In: Girling SJ, Raiti P. *BSAVA Manual of Reptiles*. Quedgeley, Gloucester: British Small Animal Veterinary Association; 2004:71–86.

113. Heatley J, Mitchell M, Williams J, et al. Fungal periodontal osteomyelitis in a

chameleon, *Furcifer pardalis*. *J Herp Med Surg*. 2001;11:7–12.

114. Heaton-Jones TG, Ko J, Heaton-Jones DL. Evaluation of medetomidine-ketamine anesthesia with atipamezole reversal in American alligators (*Alligator mississippiensis*). *J Zoo Wildl Med*. 2002;33:36–44.

115. Helmick KE, Bennett RA, Ginn P, et al. Intestinal volvulus and stricture associated with a leiomyoma in a green turtle (*Chelonia mydas*). *J Zoo Wildl Med*. 2000;31:221–227.

116. Helmick KE, Papich MG, Vliet KA, et al. Pharmacokinetic disposition of a long-acting oxytetracycline formulation after single-dose intravenous and intramuscular administrations in the American alligator (*Alligator mississippiensis*). *J Zoo Wildl Med*. 2004;35:341–346.

117. Helmick KE, Papich MG, Vliet KA, et al. Pharmacokinetics of enrofloxacin after single-dose oral and intravenous administration in the American alligator (*Alligator mississippiensis*). *J Zoo Wildl Med*. 2004;35:333–340.

118. Hernandez-Divers SJ. Pulmonary candidiasis caused by *Candida albicans* in a Greek tortoise (*Testudo graeca*) and treatment with intrapulmonary amphotericin B. *J Zoo Wildl Med*. 2001;32:352–359.

119. Hernandez-Divers SJ. Diagnostic techniques. In: Mader DR, ed. *Reptile Medicine and Surgery*. 2nd ed. St. Louis: Saunders/Elsevier; 2006:490–532.

120. Hernandez-Divers SJ, Cooper JE. Hepatic lipidosis. In: Mader DR, ed. *Reptile Medicine and Surgery*. 2nd ed. St. Louis: Saunders/Elsevier; 2006:806–813.

121. Hernandez-Divers SJ, Knott CD, MacDonald J. Diagnosis and surgical treatment of thyroid adenoma-induced hyperthyroidism in a green iguana (*Iguana iguana*). *J Zoo Wildl Med*. 2001;32:465–475.

122. Hernandez-Divers SJ, Martinez-Jimenez D, Bush S, et al. Effects of allopurinol on plasma uric acid levels in normouricaemic and hyperuricaemic green iguanas (*Iguana iguana*). *Vet Rec*. 2008;162:112–115.

123. Hernandez-Divers SM. Reptile critical care. *Exotic DVM*. 2003;5(3):81–87.
124. Hess JC, Benson J, Grimm KA, et al. Minimum alveolar concentration of isoflurane and arterial blood gas values in anesthetized green iguanas, *Iguana iguana*. *J Herp Med Surg*. 2008;17:118–124.
125. Hilf M, Swanson D, Wagner R, et al. A new dosing schedule for gentamicin in blood pythons (*Python curtus*). a pharmacokinetic study. *Res Vet Sci*. 1991;50:127–130.
126. Hilf M, Swanson D, Wagner R, et al. Pharmacokinetics of piperacillin in blood pythons (*Python curtus*) and in vitro evaluation of efficacy against aerobic gram-negative bacteria. *J Zoo Wildl Med*. 1991;22:199–203.
127. Holz P, Holz RM. Evaluation of ketamine, ketamine/xylazine, and ketamine/midazolam anesthesia in red-eared sliders (*Trachemys scripta elegans*). *J Zoo Wildl Med*. 1994;25:531–537.
128. Holz PH, Burger JP, Baker R, et al. Effect of injection site on carbenicillin pharmacokinetics in the carpet python, *Morelia spilota*. *J Herp Med Surg*. 2002;12:12–16.
129. Huchzermeyer FW. Crocodiles. Biology Husbandry and Diseases. Cambridge, MA: CABI Publishing; 2003:1–337.
130. Hungerford C, Spelman L, Papich M. Pharmacokinetics of enrofloxacin after oral and intramuscular administration in savannah monitors (*Varanus exanthematicus*). *Proc Annu Conf Am Assoc Zoo Vet*; 1997:89–92.
131. Innis C, Papich M, Young D. Pharmacokinetics of metronidazole in the red-eared slider turtle (*Trachemys scripta elegans*) after single intracoelomic injection. *J Vet Pharm Therapeut*. 2007;30:168–171.
132. Innis C, Young D, Wetzlich S, et al. Plasma voriconazole concentrations in four red-eared slider turtles (*Trachemys scripta elegans*) after a single subcutaneous injection. *Proc Annu Conf Assoc Rept Amph Vet*; 2008:72.
133. Innis CJ. Observations on urinalysis of clinically normal captive tortoises.



Proc Annu Conf Assoc Rept Amph Vet; 1997:109–112.

134. Innis CJ, Boyer TH. Chelonian reproductive disorders. *Vet Clin North Am Exotic Anim Pract*. 2002;5:555–578.

135. Jacobson ER. Evaluation of the reptile patient. In: Jacobson ER, Kollias GV, Jr. *Exotic Animals*. New York: Churchill Livingstone; 1988:1–18.

136. Jacobson ER. Use of chemotherapeutics in reptile medicine. In: Jacobson ER, Kollias GV, Jr. *Exotic Animals*. New York: Churchill Livingstone; 1988:35–48.

137. Jacobson ER. Antimicrobial drug use in reptiles. In: Prescott JF, Baggot JD. *Antimicrobial Therapy in Veterinary Medicine*. Ames: Iowa State University Press; 1993:543–552.

138. Jacobson E, Kollias GV, Jr., Peters LJ. Dosages for antibiotics and parasitocides used in exotic animals. *Compend Cont Educ Pract Vet*. 1983;5:315–324.

139. Jacobson E, Harman G, Laille E, et al. Plasma concentrations of praziquantel in loggerhead sea turtles (*Caretta caretta*) following oral administration of single and multiple doses. *Proc Annu Conf Assoc Rept Amph Vet*; 2002:37–39.

140. Jacobson ER, Brown MP, Chung M, et al. Serum concentration and disposition kinetics of gentamicin and amikacin in juvenile American alligators. *J Zoo Anim Med*. 1988;19:188–194.

141. Jarchow JL. Hospital care of the reptile patient. In: Jacobson ER, Kollias GV, Jr. *Exotic Animals*. New York: Churchill Livingstone; 1988:19–34.

142. Jenkins JR. A formulary for reptile and amphibian medicine. *Proc 4th Annu Avian/Exotic Anim Med Symp*. Davis: University of California; 1991:24–27.

143. Jenkins JR. Medical management of reptile patients. *Compend Cont Educ Pract Vet*. 1991;13:980–988.

144. Jenkins JR. Husbandry and diseases of Old World chameleons. *J Small Exotic Anim Med*. 1992;1:166–171.

145. Jepson L. Lizards. *Exotic Animal Medicine. A Quick Reference Guide*. Philadelphia: Saunders/Elsevier; 2009:268–314.
146. Jepson L. Snakes. *Exotic Animal Medicine. A Quick Reference Guide*. Philadelphia: Saunders/Elsevier; 2009:315–357.
147. Jepson L. Turtles and tortoises. *Exotic Animal Medicine. A Quick Reference Guide*. Philadelphia: Saunders/Elsevier; 2009:358–411.
148. Johnson JD, Mangone B, Jarchow JL. A review of mycoplasmosis infections in tortoises and options for treatment. *Proc Annu Conf Assoc Rept Amph Vet*; 1998:89–92.
149. Johnson JH. Anesthesia, analgesia, and euthanasia of reptiles and amphibians. *Proc Annu Conf Am Assoc Zoo Vet*; 1991:132–138.
150. Johnson JH, Benson PA. Laboratory reference values for a group of captive ball pythons (*Python regius*). *Am J Vet Res*. 1996;57:1304–1307.
151. Johnson JH, Jensen JM, Brumbaugh GW, et al. Amikacin pharmacokinetics and the effects of ambient temperature on the dosage regimen in ball pythons (*Python regius*). *J Zoo Wildl Med*. 1997;28:80–88.
152. Judd HL, Laughlin GA, Bacon JP, et al. Circulating androgen and estrogen concentrations in lizards (*Iguana iguana*). *Gen Comp Endocrinol*. 1976;30:391–395.
153. Kaufman GE, Seymour RE, Bonner BB, et al. Use of rocuronium for endotracheal intubation of North American Gulf Coast box turtles. *J Am Vet Med Assoc*. 2003;222:1111–1115.
154. Kirchgessner M, Mitchell MA. Chelonians. In: Mitchell MA, Tully TN, Jr. *Manual of Exotic Pet Practice*. St. Louis: Saunders/Elsevier; 2009:207–249.
155. Kirchgessner M, Mitchell M, Domenzain L, et al. Evaluating the effect of leuprolide acetate on testosterone levels in captive male green iguanas (*Iguana iguana*). *J Herp Med Surg*. 2009;19:128–131.

156. Klaphake E. A fresh look at metabolic bone diseases in reptiles and amphibians. *Vet Clin North Am Exotic Anim Pract*. 2010;13:375–392.
157. Klaphake E. Personal observation; 2011.
158. Klingenberg RJ. A comparison of fenbendazole and ivermectin for the treatment of nematode parasites in ball pythons. *Python regius. Bull Assoc Rept Amph Vet*. 1992;2:5–6.
159. Klingenberg RJ. Management of the anorectic ball python. *Proc North Am Vet Conf*; 1996:830.
160. Klingenberg RJ. Therapeutics. In: Mader DR, ed. *Reptile Medicine and Surgery*. Philadelphia: WB Saunders Co; 1996:299–321.
161. Klingenberg RJ. Diagnosing parasites of Old World chameleons. *Exotic DVM*. 2000;1(6):17–21.
162. Klingenberg RJ. Understanding Reptile Parasites. Irvine, CA: Advanced Vivarium Systems; 2007:1–200.
163. Knotkova Z, Doubek J, Knotek Z, et al. Blood cell morphology and plasma biochemistry in Russian tortoises (*Agrionemys horsfieldi*). *Acta Vet Brno*. 2002;71:191–198.
164. Koelle P. Urinalysis in tortoises. *Proc Annu Conf Assoc Rept Amph Vet*; 2000:111–113.
165. Koelle P. Efficacy of allopurinol in European tortoises with hyperuricemia. *Proc Annu Conf Assoc Rept Amph Vet*; 2001:185–186.
166. Koelle P, Hoffmann R. Urinalysis in European tortoises—part II. *Proc Annu Conf Assoc Rept Amph Vet*; 2002:117.
167. Kolmstetter CM, Cox S, Ramsay EC. Pharmacokinetics of metronidazole in the yellow rat snake, *Elaphe obsoleta quadrivittata*. *J Herp Med Surg*. 2001;11:4–8.

168. Kolmstetter CM, Frazier D, Cox S, et al. Pharmacokinetics of metronidazole in the green iguana, *Iguana iguana*. *Bull Assoc Rept Amph Vet*. 1998;8:4–7.
169. Lane T. Crocodilians. In: Mader DR, ed. *Reptile Medicine and Surgery*. 2nd ed. St. Louis: Saunders/Elsevier; 2006:100–117.
170. Lawrence K, Muggleton PW, Needham JR. Preliminary study on the use of ceftazidime, a broad spectrum cephalosporin antibiotic, in snakes. *Res Vet Sci*. 1984;36:16–20.
171. Lawrence K, Palmer GH, Needham JR. Use of carbenicillin in 2 species of tortoise (*Testudo graeca* and *Testudo hermanni*). *Res Vet Sci*. 1986;40:413–415.
172. Lawrence K, Needham JR, Palmer GH, et al. A preliminary study on the use of carbenicillin in snakes. *J Vet Pharmacol Therapeut*. 1984;7:119–124.
173. Lawton MPC. Anaesthesia. In: Benyon PH, Lawton MPC, Cooper JE. *Manual of Reptiles*. Ames: Iowa State University Press; 1992:170–183.
174. Lawton MPC. Pain management after surgery. *Proc North Am Vet Conf*; 1999:782.
175. Lloyd M. Crocodilia. In: Fowler ME, Miller RE. *Zoo and Wild Animal Medicine*. 5th ed. Philadelphia: Saunders/Elsevier; 2003:59–70.
176. Lloyd ML. Reptilian dystocias review—causes, prevention, management, and comments on the synthetic hormone vasotocin. *Proc Annu Conf Am Assoc Zoo Vet*; 1990:290–296.
177. Lloyd ML. Crocodilian anesthesia. In: Fowler ME, Miller RE. *Zoo and Wild Animal Medicine: Current Therapy 4*. Philadelphia: WB Saunders Co; 1999:205–216.
178. Lloyd ML, Reichard T, Odum RA. Gallamine reversal in Cuban crocodiles (*Crocodilus rhombifer*) using neostigmine alone vs. neostigmine with hyaluronidase. *Proc Annu Conf Assoc Rept Amph Vet*; 1994:117–120.
179. Lock BA, Heard DJ, Dennis P. Preliminary evaluation of

medetomidine/ketamine combinations for immobilization and reversal with atipamezole in three tortoise species. *Bull Assoc Rept Amph Vet*. 1998;8:6–9.

180. Luppi M, Costa M, Malta M, et al. Treatment of *Rhabdias labiata* with levamisole and ivermectin in boa constrictor (*Boa constrictor amarali*). *Veterinaria Noticias*. 2007;13:61–65.

181. Machado CC, Silva LFN, Ramos PRR, et al. Seasonal influence on hematologic values and hemoglobin electrophoresis in Brazilian *Boa constrictor amarali*. *J Zoo Wildl Med*. 2006;37:487–491.

182. Mader DR. IME—Use of calcitonin in green iguanas, *Iguana iguana*, with metabolic bone disease. *Bull Assoc Rept Amph Vet*. 1993;3:5.

183. Mader DR. Gout. In: Mader DR, ed. *Reptile Medicine and Surgery*. Philadelphia: WB Saunders Co; 1996:374–379.

184. Mader DR. Reproductive surgery of the green iguana. *Semin Avian Exotic Pet Med*. 1996;5:214–221.

185. Mader DR. Specific diseases and conditions. In: Mader DR, ed. *Reptile Medicine and Surgery*. Philadelphia: WB Saunders Co; 1996:341–346.

186. Mader DR. Understanding local analgesics. practical use in the green iguana, *Iguana iguana*. *Proc Annu Conf Assoc Rept Amph Vet*; 1998:143–147.

187. Mader DR. Metabolic bone diseases. In: Mader DR, ed. *Reptile Medicine and Surgery*. 2nd ed. St Louis: Saunders/Elsevier; 2006:841–851.

188. Mader DR. Thermal burns. In: Mader DR, ed. *Reptile Medicine and Surgery*. 2nd ed. St Louis: Saunders/Elsevier; 2006:916–923.

189. Mader DR. *Antimicrobial therapy in reptiles*. *Proc South Euro Vet Conf Congresso Nacional AVEPA*; 2007.

190. Mader DR. Personal communication; 2011.

191. Mader DR, Rudloff E. Emergency and critical care. In: Mader DR, ed. *Reptile*

*Medicine and Surgery*. 2nd ed. St Louis: Saunders/Elsevier; 2006:533–548.

192. Mader DR, Conzelman GM, Baggot JD. Effects of ambient temperature on half life and dosage regimen of amikacin in the gopher snake. *J Am Vet Med Assoc*. 1985;187:1134–1136.
193. Mader DR, Horvath CC, Paul-Murphy J. The hematocrit and serum profile of the gopher snake (*Pituophis melanoleucas catenifer*). *J Zoo Anim Med*. 1985;16:139–140.
194. Mallo KM, Harms CA, Lewbart GA, et al. Pharmacokinetics of fluconazole in loggerhead sea turtles (*Caretta caretta*) after single intravenous and subcutaneous injections, and multiple subcutaneous injections. *J Zoo Wildl Med*. 2002;33:29–35.
195. Manire CA, Hunter RP, Koch DE, et al. Pharmacokinetics of ticarcillin in the loggerhead sea turtle (*Caretta caretta*) after single intravenous and intramuscular injections. *J Zoo Wildl Med*. 2005;36:44–53.
196. Manire CA, Rhinehart HL, Pennick GJ, et al. Steady-state plasma concentrations of itraconazole after oral administration in Kemp's ridley sea turtles, *Lepidochelys kempi*. *J Zoo Wildl Med*. 2003;34:171–178.
197. Marin P, Bayon A, Fernandez-Varon E, et al. Pharmacokinetics of danofloxacin after single dose intravenous, intramuscular, and subcutaneous administration to loggerhead turtles *Caretta caretta*. *Dis Aquat Organ*. 2008;82:231–236.
198. Marks SK, Citino SB. Hematology and serum chemistry of the radiated tortoise (*Testudo radiata*). *J Zoo Wildl Med*. 1990;21:342–344.
199. Martel A, Hellebuyck T, Van Waeyenberghe L. Treatment of infections with *Nannizziopsis vriesii*, an emergent reptilian dermatophyte. *Proc Annu Conf Assoc Rept Amph Vet*; 2009:69–70.
200. Martelli P, Lai OR, Krishnasamy K, et al. Pharmacokinetic behavior of enrofloxacin in estuarine crocodile (*Crocodylus porosus*) after single intravenous, intramuscular, and oral doses. *J Zoo Wildl Med*. 2009;40:696–704.

201. Martinez-Jimenez D, Hernandez-Divers SJ. Emergency care of reptiles. *Vet Clin North Am Exotic Anim Pract*. 2007;10:557–585.
202. Mathes KA, Holz A, Fehr M. Blood reference values of terrestrial tortoises (*Testudo* spp.) kept in Germany. *Tierarztl Prax Ausg K Klientiere Heimtiere*. 2006;34:268–274.
203. Mauldin GN, Done LB. Oncology. In: Mader DR, ed. *Reptile Medicine and Surgery*. 2nd ed. St Louis: Saunders/Elsevier; 2006:299–322.
204. Mautino M, Page CD. Biology and medicine of turtles and tortoises. *Vet Clin North Am Small Anim Pract*. 1993;23:1251–1270.
205. Maxwell LK, Jacobson ER. Preliminary single-dose pharmacokinetics of enrofloxacin after oral and intramuscular administration in green iguanas (*Iguana iguana*). *Proc Annu Conf Am Assoc Zoo Vet*; 1997:25.
206. Mayer J. Characterizing the hematologic and plasma chemistry profiles of captive Chinese water dragons, *Physignathus cocincinus*. *J Herp Med Surg*. 2005;15:45–52.
207. McArthur S. Problem solving approach to common diseases of terrestrial and semi-aquatic chelonians. In: McArthur S, Wilkinson R, Meyer J. *Medicine and Surgery of Tortoises and Turtles*. Oxford: Blackwell Publishing Ltd; 2004:309–377.
208. McArthur SDJ, Wilkinson RJ, Barrows MG. Tortoises and turtles. In: Meredith A, Redrobe S. *BSAVA Manual of Exotic Pets*. 4th ed. Gloucestershire: British Small Animal Veterinary Association; 2002:208–222.
209. McBride M, Hernandez-Divers SJ, Koch T, et al. Preliminary evaluation of pre- and post-prandial 3[alpha]-hydroxy bile acids in the green iguana, *Iguana iguana*. *J Herp Med Surg*. 2006;16:129–134.
210. McFarlen J. Commonly occurring reptilian internal parasites. *Proc Annu Conf Am Assoc Zoo Vet*; 1991:120–127.
211. McKeown S. General husbandry and management. In: Mader DR, ed. *Reptile*

*Medicine and Surgery*. Philadelphia: WB Saunders Co; 1996:9–19.

212. Mehler SJ, Bennett RA. Upper alimentary tract disease. In: Mader DR, ed. *Reptile Medicine and Surgery*. 2nd ed. St Louis: Saunders/Elsevier; 2006:924–930.

213. Mehlhorn H, Schmahl G, Frese M, et al. Effects of a combinations of emodepside and praziquantel on parasites of reptiles and rodents. *Parasitol Res*. 2005;97(Suppl 1):S65–S69.

214. Messonnier S. Formulary for exotic pets. *Vet Forum*; 1996:46–49. Aug

215. Meyer J. Gastrographin as a gastrointestinal contrast agent in the Greek tortoise (*Testudo hermanni*). *J Zoo Wildl Med*. 1998;29:183–189.

216. Miller HA, Brandt PJ, Frye FL, et al. Trichomonas associated with ocular and subcutaneous lesions in geckos. *Proc Annu Conf Assoc Rept Amph Vet*; 1994:102–107.

217. Millichamp NJ. Surgical techniques in reptiles. In: Jacobson ER, Kollias GV, Jr. *Exotic Animals*. New York: Churchill Livingstone; 1988:49–74.

218. Millichamp NJ. Ophthalmology. In: Girling SJ, Raiti P. *BSAVA Manual of Reptiles*. 2nd ed. Quedgeley, Gloucester: British Small Animal Veterinary Association; 2004:199–209.

219. Mitchell M. Ophidia. In: Fowler ME, Miller RE. *Zoo and Wild Animal Medicine*. 5th ed. Philadelphia: Saunders/Elsevier; 2003:82–91.

220. Mitchell MA. Therapeutics. In: Mader DR, ed. *Reptile Medicine and Surgery*. 2nd ed. St Louis: Saunders/Elsevier; 2006:631–664.

221. Mitchell MA. Ponazuril. *J Exotic Pet Med*. 2008;17:228–229.

222. Mitchell MA. Managing the reptile patient in the veterinary hospital. establishing a standards of care model for nontraditional species. *J Exotic Pet Med*. 2010;19:56–72.



223. Montali RJ, Bush M, Smeller JM. Pathology of nephrotoxicity of gentamicin in snakes—model for reptilian gout. *Vet Pathol*. 1979;16:108–115.
224. Morgan-Davies AM. Immobilization of the Nile crocodile (*Crocodilus niloticus*) with gallamine triethiodide. *J Zoo Anim Med*. 1980;11:85–87.
225. Murray MJ. Aural abscesses. In: Mader DR, ed. *Reptile Medicine and Surgery*. 2nd ed. St Louis: Saunders/Elsevier; 2006:742–746.
226. Murray MJ. Pneumonia and lower respiratory tract disease. In: Mader DR, ed. *Reptile Medicine and Surgery*. 2nd ed. St Louis: Saunders/Elsevier; 2006:865–877.
227. Naldo JL, Libanan NL, Samour JH. Health assessment of a spiny-tailed lizard (*Uromastix* spp.) population in Abu Dhabi, United Arab Emirates. *J Zoo Wildl Med*. 2009;40:445–452.
228. Naples LM, Langan JN, Mylniczenko ND, et al. Islet cell tumor in a Savannah monitor (*Varanus exanthematicus*). *J Herp Med Surg*. 2009;19:97–105.
229. Nathan R. Treatment with oviductal catheterization, prostaglandin E<sub>2</sub> then prostaglandin F<sub>2α</sub> to aid oviposition in a spotted python, *Antaresia maculosa*. *Bull Assoc Rept Amph Vet*. 1996;6:4.
230. Neiffer DL, Lydick D, Burks K, et al. Hematologic and plasma biochemical changes associated with fenbendazole administration in Hermann's tortoises (*Testudo hermanni*). *J Zoo Wildl Med*. 2005;36:661–672.
231. Nevarez JG, Mitchell MA, Wilkelski M. Evaluating the clinical effects of propofol in marine iguanas (*Amblyrhynchus cristatus*). *Proc Annu Conf Assoc Rept Amph Vet*; 2003:97–105.
232. Nevarez JG, Mitchell MA, Le Blanc C, et al. Determination of plasma biochemistries, ionized calcium, vitamin D<sub>3</sub>, and hematocrit values in captive green iguanas (*Iguana iguana*) from El Salvador. *Proc Annu Conf Assoc Rept Amph Vet*; 2002:87–91.
233. Nichols DK, Lamirande EW. Use of methohexital sodium as an anesthetic in

- two species of colubrid snakes. *Proc Joint Conf Am Assoc Zoo Vet/Assoc Rept Amph Vet*; 1994:161–162.
234. Norton TM. Chelonian emergency and critical care. *Semin Avian Exotic Pet Med*. 2005;14:106–130.
235. Norton TM, Jacobson ER, Caligiuri R, et al. Medical management of a Galapagos tortoise (*Geochelone elephantopus*) with hypothyroidism. *J Zoo Wildl Med*. 1989;20:212–216.
236. Norton TM, Spratt J, Behler J, et al. Medetomidine and ketamine anesthesia with atipamezole reversal in free-ranging gopher tortoises, *Gopherus polyphemus*. *Proc Annu Conf Assoc Rept Amph Vet*; 1998:25–27.
237. Oonincx DGAB, Stevens Y, van den Borne JJGC, et al. Effects of vitamin D-3 supplementation and UVB exposure on the growth and plasma concentration of vitamin D-3 metabolites in juvenile bearded dragons (*Pogona vitticeps*). *Comp Biochem Physiol B Biochem Mol Biol*. 2010;156:122–128.
238. Oppenheim YC, Moon PF. Sedative effects of midazolam in red-eared sliders (*Trachemys scripta elegans*). *J Zoo Wildl Med*. 1995;26:409–413.
239. Origgi F, Roccabianca P, Gelmetti D. Dermatophilosis in *Furcifer pardalis* (Chamaleo). *Bull Assoc Rept Amph Vet*. 1999;9:9–11.
240. O'Shea R, Ball RL. Use of bovine tendon collagen for wound repair in *Varanus komodoensis*. *Proc Annu Conf Assoc Rept Amph Vet*; 2010:66–69.
241. Pace L, Mader DR. Atropine and glycopyrrolate, route of administration and response in the green iguana (*Iguana iguana*). *Proc Annu Conf Assoc Rept Amph Vet*; 2002:79.
242. Page CD. Current reptilian anesthesia procedures. In: Fowler ME, ed. *Zoo and Wild Animal Medicine: Current Therapy 3*. Philadelphia: WB Saunders Co; 1993:140–143.
243. Page CD, Mautino M. Clinical management of tortoises. *Compend Cont Educ Pract Vet*. 1990;12:79–85.

244. Page CD, Mautino M, Derendorf H, et al. Multiple dose pharmacokinetics of ketoconazole administered orally to gopher tortoises (*Gopherus polyphemus*). *J Zoo Wildl Med*. 1991;22:191–198.
245. Paré JA, Crawshaw GJ, Barta JR. Treatment of cryptosporidiosis in Gila monsters (*Heloderma suspectum*) with paromomycin. *Proc Annu Conf Assoc Rept Amph Vet*; 1997:23.
246. Plumb DC. Probenecid. In: Plumb DC, ed. *Plumb's Veterinary Drug Handbook*. 6th ed. Ames: Blackwell Publishing; 2008:1028–1030.
247. Praschag P, Gibbons P, Boyer T, et al. An outbreak of intranuclear coccidiosis in *Pyxis* spp. tortoises. *Proc 8th Annu Symp Conserv Biol Tortoises Freshwater Turtles*; 2010:42–43.
248. Preston DL, Mosley CAE, Mason RT. Sources of variability in recovery time from methohexital sodium anesthesia in snakes. *Copeia*. 2010;3:496–501.
249. Prezant RM, Isaza R, Jacobson ER. Plasma concentrations and disposition kinetics of enrofloxacin in gopher tortoises (*Gopherus polyphemus*). *J Zoo Wildl Med*. 1994;25:82–87.
250. Pye GW, Carpenter JW. Ketamine sedation followed by propofol anesthesia in a slider, *Trachemys scripta*, to facilitate removal of an esophageal foreign body. *Bull Assoc Rept Amph Vet*. 1998;8:16–17.
251. Quesada RJ, Aitken-Palmer C, Conley K, et al. Accidental submeningeal injection of propofol in gopher tortoises (*Gopherus polyphemus*). *Vet Rec*. 2010;167:494–495.
252. Raiti P. Veterinary care of the common kingsnake, *Lampropeltis getula*. *Bull Assoc Rept Amph Vet*. 1995;5:11–18.
253. Raiti P. Administration of aerosolized antibiotics in reptiles. *Exotic DVM*. 2002;4(3):87–90.
254. Ramsay EC, Dotson TK. Tissue and serum enzyme activities in the yellow rat snake (*Elaphe obsoleta quadrivittata*). *Am J Vet Res*. 1995;56:423–428.

255. Raphael B, Clark CH, Hudson R, Jr. Plasma concentration of gentamicin in turtles. *J Zoo Anim Med*. 1985;16:136–139.
256. Raphael BL. Chelonians. In: Fowler ME, Miller RE. *Zoo and Wild Animal Medicine*. 5th ed. Philadelphia: Saunders/Elsevier; 2003:48–58.
257. Raphael BL, Papich M, Cook RA. Pharmacokinetics of enrofloxacin after a single intramuscular injection in Indian star tortoises (*Geochelone elegans*). *J Zoo Wildl Med*. 1994;25:88–94.
258. Redrobe S, MacDonald J. Sample collection and clinical pathology of reptiles. *Vet Clin North Am Exotic Anim Pract*. 1999;2:709–730.
259. Rivera S. Health assessment of the reptilian reproductive tract. *J Exotic Pet Med*. 2008;17:259–266.
260. Rojo-Solís C, Ros-Rodriguez JM, Valls M. Pharmacokinetics of meloxicam (Metacam) after intravenous, intramuscular, and oral administration in red-eared slider turtles (*Trachemys scripta elegans*). *Proc Joint Conf Am Assoc Zoo Vet/Am Assoc Wildl Vet*; 2009:228.
261. Rooney MB, Levine G, Gaynor J, et al. Sevoflurane anesthesia in desert tortoises (*Gopherus agassizii*). *J Zoo Wildl Med*. 1999;30:64–69.
262. Rosenthal K. Chemotherapeutic treatment of a sarcoma in a corn snake. *Proc Joint Conf Am Assoc Zoo Vet/Assoc Rept Amph Vet*; 1994:46.
263. Rossi J. Practical reptile dermatology. *Proc North Am Vet Conf*; 1995:648–649.
264. Rossi JV. Emergency medicine of reptiles. *Proc North Am Vet Conf*; 1998:799–801.
265. Schaeffer DO. Anesthesia and analgesia in nontraditional laboratory animal species. In: Kohn DF, Wixson SK, White WJ, et al. *Anesthesia and Analgesia in Laboratory Animals*. New York: Academic Press; 1997:338–378.
266. Scheelings TF, Holz P, Haynes L, et al. A preliminary study of the chemical

restraint of selected squamate reptiles with alfaxalone. *Proc Annu Conf Assoc Rept Amph Vet*; 2010:114–115.

267. Schilliger L, Betremieux O, Rochet J, et al. Absorption and efficacy of a spot-on combination containing emodepside plus praziquantel in reptiles. *Rev Med Vet (Toulouse)*. 2009;160:557–561.

268. Schnellbacher R. Butorphanol. *J Exotic Pet Med*. 2010;19:192–195.

269. Schobert E. Telazol use in wild and exotic animals. *Vet Med*. 1987;82:1080–1088.

270. Schumacher J. Reptiles and amphibians. In: Thurman JC, Tranquilli WJ, Benson GJ. *Lumb and Jones' Veterinary Anesthesia*. 3rd ed. Baltimore: Williams & Wilkins; 1996:670–685.

271. Schumacher J. Respiratory diseases of reptiles. *Semin Avian Exotic Pet Med*. 1997;6:209–215.

272. Schumacher J. Lacertilia. In: Fowler ME, Miller RE. *Zoo and Wild Animal Medicine*. 5th ed. Philadelphia: Saunders/Elsevier; 2003:73–81.

273. Schumacher J, Yelen T. Anesthesia and analgesia. In: Mader DR, ed. *Reptile Medicine and Surgery*. 2nd ed. St Louis: Saunders/Elsevier; 2006:442–452.

274. Sladky KK, Kinney ME, Johnson SM. Analgesic efficacy of butorphanol and morphine in bearded dragons and corn snakes. *J Am Vet Med Assoc*. 2008;233:267–273.

275. Sladky KK, Kinney ME, Johnson SM. Effects of opioid receptor activation on thermal antinociception in red-eared slider turtles (*Trachemys scripta*). *Am J Vet Res*. 2009;70:1072–1078.

276. Sladky KK, Miletic V, Paul-Murphy J, et al. Analgesic efficacy and respiratory effects of butorphanol and morphine in turtles. *J Am Vet Med Assoc*. 2007;230:1356–1362.

277. Sleeman JM, Gaynor J. Sedative and cardiopulmonary effects of

medetomidine and reversal with atipamezole in desert tortoises (*Gopherus agassizii*). *J Zoo Wildl Med*. 2000;31:28–35.

278. Smith JA, McGuire NC, Mitchell MA. Cardiopulmonary physiology and anesthesia in crocodilians. *Proc Annu Conf Assoc Rept Amph Vet*; 1998:17–21.

279. Spiegel RA, Lane TA, Larsen RE. Diazepam and succinylcholine for restraint of the American alligator. *J Am Vet Med Assoc*. 1984;185:1335–1336.

280. Spörle H, Gobel T, Schildger B. Blood levels of some anti-infectives in the spur-thighed tortoise (*Testudo hermanni*). *Proc 4th Intl Colloq Path Med Rept Amph*; 1991:120–128.

281. Stahl SJ. Captive management, breeding, and common medical problems of the veiled chameleon (*Chamaeleo calyptratus*). *Proc Annu Conf Assoc Rept Amph Vet*; 1997:29–40.

282. Stahl SJ. Common diseases of the green iguana. *Proc North Am Vet Conf*; 1998:806–809.

283. Stahl SJ. Reproductive disorders of the green iguana. *Proc North Am Vet Conf*; 1998:810–813.

284. Stahl SJ. Medical management of bearded dragons. *Proc North Am Vet Conf*; 1999:789–792.

285. Stahl SJ. Diseases of the reptile pancreas. *Vet Clin North Am Exotic Anim Pract*. 2003;6:191–212.

286. Stahl SJ. Pet lizard conditions and syndromes. *Semin Avian Exotic Pet Med*. 2003;12:162–182.

287. Stahl SJ. Clinician's approach to the chameleon patient. *Proc North Am Vet Conf*; 2006:1667–1670.

288. Stahl S, Donoghue S. Pharyngostomy tube placement, management and use for nutritional support in chelonian patients. *Proc Annu Conf Assoc Rept Amph Vet*; 1997:93–97.

289. Stamper MA, Papich MG, Lewbart GA, et al. Pharmacokinetics of ceftazidime in loggerhead sea turtles (*Caretta caretta*) after single intravenous and intramuscular injections. *J Zoo Wildl Med*. 1999;30:32–35.
290. Stegman N, Heatley JJ. The use of haloperidol in mitigation of human-directed aggression in boid snakes. *Proc Annu Conf Assoc Rept Amph Vet*; 2010:113.
291. Stein G. Reptile and amphibian formulary. In: Mader DR, ed. *Reptile Medicine and Surgery*. Philadelphia: WB Saunders Co; 1996:465–472.
292. Stirl R, Krug P, Bonath KH. Tiletamine/zolazepam sedation in boa constrictors and its influence on respiration, circulation, and metabolism. *Proc Conf Euro Assoc Zoo Wildl Vet*; 1996:115–119.
293. Suedmeyer WK. Iron deficiency in a group of American alligators. diagnosis and treatment. *J Small Exotic Anim Med*. 1991;1:69–72.
294. Sykes JM. Updates and practical approaches to reproductive disorders in reptiles. *Vet Clin North Am Exotic Anim Pract*. 2010;13:349–373.
295. Sykes JM, Ramsay EC, Schumacher J, et al. Evaluation of an implanted osmotic pump for delivery of amikacin to corn snakes (*Elaphe guttata guttata*). *J Zoo Wildl Med*. 2006;37:373–380.
296. Taylor RW, Jr., Jacobson ER. Hematology and serum chemistry of the gopher tortoise, *Gopherus polyphemus*. *Comp Biochem Physiol A*. 1982;72:425–428.
297. Teare JA. *Physiological Data Reference Values Project*. Apple Valley, MN: International Species Information System (ISIS); 2010.
298. Teare JA, Bush M. Toxicity and efficacy of ivermectin in chelonians. *J Am Vet Med Assoc*. 1983;183:1195–1197.
299. Tothill A, Johnson J, Branvold H, et al. Effect of cisapride, erythromycin, and metoclopramide on gastrointestinal transit time in the desert tortoise, *Gopherus agassizii*. *J Herp Med Surg*. 2000;10:16–20.

300. Troiano J, Gould E, Gould I. Hematological reference intervals in Argentine lizard *Tupinambis merianae*. *Comp Clin Path*. 2008;17:169–174.
301. Tuttle AD, Papich M, Lewbart GA, et al. Pharmacokinetics of ketoprofen in the green iguana (*Iguana iguana*) following single intravenous and intramuscular injections. *J Zoo Wildl Med*. 2006;37:567–570.
302. Van Waeyenberghe L, Baert K, Pasmans F, et al. Voriconazole, a safe alternative for treating infections caused by the *Chrysosporium* anamorph of *Nannizziopsis vriesii* in bearded dragons (*Pogona vitticeps*). *Med Mycol*. 2010;48:880–885.
303. Wellehan JFX, Gunkel CI. Emergent diseases in reptiles. *Semin Avian Exotic Pet Med*. 2004;13:160–174.
304. Whitaker BR, Krum H. Medical management of sea turtles in aquaria. In: Fowler ME, Miller ME. *Zoo and Wild Animal Medicine: Current Therapy 4*. Philadelphia: WB Saunders Co; 1999:217–231.
305. White SD, Bourdeau P, Bruet V, et al. Reptiles with dermatological lesions. a retrospective study of 301 cases at two university veterinary teaching hospitals (1992-2008). *Vet Dermatol*. 2010;22:150–161.
306. Willette-Frahm M, Wright KM, Thode BC. Select protozoal diseases in amphibians and reptiles. *Bull Assoc Rept Amph Vet*. 1995;5:19–29.
307. Wilson SC, Carpenter JW. Endoparasitic diseases of reptiles. *Semin Avian Exotic Pet Med*. 1996;5:64–74.
308. Wimsatt J, Johnson J, Mangone BA, et al. Clarithromycin pharmacokinetics in the desert tortoise (*Gopherus agassizii*). *J Zoo Wildl Med*. 1999;30:36–43.
309. Wissman MA, Parsons B. Dermatophytosis of green iguanas (*Iguana iguana*). *J Small Exotic Anim Med*. 1993;2:133–136.
310. Wood FE, Critchley KH, Wood JR. Anesthesia in green the sea turtle, *Chelonia mydas*. *Am J Vet Res*. 1982;43:1882.



311. Wozniak EJ, DeNardo DF. The biology, clinical significance and control of the common snake mite, *Ophionyssus natricis*, in captive reptiles. *J Herp Med Surg*. 2000;10:4–10.
312. Wright K. Omphalectomy of reptiles. *Exotic DVM*. 2001;3(1):11–15.
313. Wright KM. Common medical problems of tortoises. Proc North Am Vet Conf; 1997:769–771.
314. Wright KM, Skeba S. Hematology and plasma chemistries of captive prehensile-tailed skinks (*Corucia zebrata*). *J Zoo Wildl Med*. 1992;23:429–432.
315. Young LA, Schumacher J, Papich MG, et al. Disposition of enrofloxacin and its metabolite ciprofloxacin after intravascular injection in juvenile Burmese pythons (*Python molurus bivittatus*). *J Zoo Wildl Med*. 1997;28:71–79.
316. Zaias J, Norton T, Fickel A, et al. Biochemical and hematologic values for 18 clinically healthy radiated tortoises (*Geochelone radiata*) on St Catherines Island, Georgia. *Vet Clin Pathol*. 2006;35:321–325.
317. Ziolo M, Bertelsen M. Effects of propofol administered via the supravertebral sinus in red-eared sliders. *J Am Vet Med Assoc*. 2009;234:390–393.

Birds

Michelle G. Hawkins, Heather W. Barron, Brian L. Speer, Christal Pollock, James W. Carpenter

TABLE 5-1 Antimicrobial Agents Used in Birds.<sup>a</sup>

| Agent    | Dosage                                       | Species/Comments                                                                                                      |
|----------|----------------------------------------------|-----------------------------------------------------------------------------------------------------------------------|
| Amikacin | —                                            | Least nephrotoxic of the aminoglycosides; <sup>165</sup> maintain hydration during use <sup>5</sup>                   |
|          | 7 mg/kg IV q24h <sup>344</sup>               | Emus/PD; mean serum levels declined below a target trough of 4 µg/mL at 24 hr                                         |
|          | 7.6 mg/kg IM q8h <sup>383</sup>              | Ostriches/PD; causes myositis; painful injection                                                                      |
|          | 10 mg/kg IM q12h <sup>577</sup>              | Cranes                                                                                                                |
|          | 10 mg/kg SC, IM q8h × 14 days <sup>426</sup> | Ring-necked pheasants/PD; renal toxicosis appeared at 11 days; uric acid levels abnormal up to 7 days after cessation |
|          | 10-15 mg/kg IM q24h <sup>363</sup>           | Raptors                                                                                                               |
|          | 10-15 mg/kg IM q12h <sup>481</sup>           | Amazon parrots, cockatiels, cockatoos/PD                                                                              |
|          | 10-15 mg/kg IM, IV q8-12h <sup>702,812</sup> | Most species, including psittacines                                                                                   |
|          | 10-20 mg/kg IM, IV q8-12h <sup>303</sup>     | African grey parrots/PD                                                                                               |
|          | 15 mg/kg IM q12h <sup>724</sup>              | Blue-fronted Amazon parrots/PD                                                                                        |
|          | 15 mg/kg IV q8h <sup>724</sup>               | Blue-fronted Amazon parrots/PD                                                                                        |
|          | 15-20 mg/kg/day divided q8-24h <sup>73</sup> | Red-tailed hawks/PD; use low end of dose range for smaller hawks                                                      |
|          | 15-20 mg/kg SC, IM, IV q8-12h <sup>200</sup> | Passerines, pigeons/5 days maximum <sup>693</sup>                                                                     |
|          | 15-20 mg/kg IM q8-12h <sup>643</sup>         | Cockatiels/PD                                                                                                         |
|          | 15-30 mg/kg IM q12-24h <sup>200,824</sup>    | Most species, including passerines/use in combination with other agents for                                           |

|                                            |                                                          |                                                                                                                                                                                                                                                                                                                                                                              |
|--------------------------------------------|----------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                                            |                                                          | <i>Mycobacterium</i> ; see <a href="#">Table 5-45</a>                                                                                                                                                                                                                                                                                                                        |
|                                            | 20 mg/kg IM q12h <sup><a href="#">1</a></sup>            | Ostriches (chicks)/administer concurrent to piperacillin (100 mg/kg q12h)                                                                                                                                                                                                                                                                                                    |
|                                            | 20 mg/kg IM q8h <sup><a href="#">214</a></sup>           | Chickens/PD                                                                                                                                                                                                                                                                                                                                                                  |
|                                            | 528 mg/L drinking water <sup><a href="#">810</a></sup>   | Ratites/egg dip                                                                                                                                                                                                                                                                                                                                                              |
|                                            | 3 g/40 packet bone cement <sup><a href="#">814</a></sup> | PMMA bead formation (1:14 ratio); same dose for all aminoglycoside beads                                                                                                                                                                                                                                                                                                     |
| Amoxicillin/clavulanate (Clavamox, Pfizer) | —                                                        | β-lactamase inhibitor; use with allopurinol is contraindicated <sup><a href="#">5</a></sup>                                                                                                                                                                                                                                                                                  |
|                                            | 7-14 mg/kg IM q24h <sup><a href="#">102</a></sup>        | Ostriches                                                                                                                                                                                                                                                                                                                                                                    |
|                                            | 10-15 mg/kg PO q12h <sup><a href="#">810</a></sup>       | Ratites                                                                                                                                                                                                                                                                                                                                                                      |
|                                            | 60-120 mg/kg IM q8-12h <sup><a href="#">201</a></sup>    | Collared doves/PD                                                                                                                                                                                                                                                                                                                                                            |
|                                            | 125 mg/kg PO q12h <sup><a href="#">259,609</a></sup>     | Most species, including pigeons, psittacines, raptors                                                                                                                                                                                                                                                                                                                        |
|                                            | 125 mg/kg PO q6h <sup><a href="#">147</a></sup>          | Psittacines                                                                                                                                                                                                                                                                                                                                                                  |
|                                            | 125 mg/kg PO q8h <sup><a href="#">586</a></sup>          | Blue-fronted Amazon parrots/PD                                                                                                                                                                                                                                                                                                                                               |
|                                            | 125-250 mg/kg PO q8-12h <sup><a href="#">201</a></sup>   | Collared doves/PD                                                                                                                                                                                                                                                                                                                                                            |
|                                            | 500 mg/L drinking water <sup><a href="#">872</a></sup>   | Chickens/PD                                                                                                                                                                                                                                                                                                                                                                  |
| Amoxicillin sodium                         | 50 mg/kg IM q12-24h <sup><a href="#">199</a></sup>       | Pigeons/PD; gram-positive bacteria                                                                                                                                                                                                                                                                                                                                           |
|                                            | 100 mg/kg IM, IV q4-8h <sup><a href="#">702</a></sup>    | Bustards/PD; administer q4h IM or q8h IV to maintain blood levels >2 mg/mL                                                                                                                                                                                                                                                                                                   |
|                                            | 150 mg/kg IM q8h <sup><a href="#">696</a></sup>          | Passerines, soft bills                                                                                                                                                                                                                                                                                                                                                       |
|                                            | 250 mg/kg IM q12-24h <sup><a href="#">195,199</a></sup>  | Pigeons/PD; gram-positive and gram-negative bacteria                                                                                                                                                                                                                                                                                                                         |
| Amoxicillin trihydrate                     | —                                                        | Broad-spectrum bactericidal penicillin antibiotic; <sup><a href="#">5</a></sup> minimal activity for common gram-negative infections of birds; <sup><a href="#">702</a></sup> because amoxicillin has a relatively low availability after oral administration, higher doses are needed in birds to achieve the same peak levels as in mammals <sup><a href="#">204</a></sup> |
|                                            | 15-22 mg/kg PO q8h <sup><a href="#">810</a></sup>        | Ratites                                                                                                                                                                                                                                                                                                                                                                      |

|  |                                                                                                                                |                                        |
|--|--------------------------------------------------------------------------------------------------------------------------------|----------------------------------------|
|  | 20 mg/kg PO q12-24h <sup><a href="#">197</a></sup>                                                                             | Pigeons/PD; mean half-life 66 min      |
|  | 30 mg/kg IM q12h × 5 days <sup><a href="#">102</a></sup>                                                                       | Pigeons                                |
|  | 40-80 mg/kg PO q12h × 5 days <sup><a href="#">102</a></sup>                                                                    | Pigeons                                |
|  | 55-110 mg/kg PO q12h <sup><a href="#">320</a></sup>                                                                            | Pigeons                                |
|  | 100 mg/kg PO q12-24h <sup><a href="#">205</a></sup>                                                                            | Pigeons/PD                             |
|  | 100 mg/kg PO q8h <sup><a href="#">50</a></sup>                                                                                 | Most species, including raptors        |
|  | 100-150 mg/kg PO q12h <sup><a href="#">149</a></sup>                                                                           | Raptors                                |
|  | 100-200 mg/kg PO, IM q4-8h <sup><a href="#">205</a></sup>                                                                      | Pigeons                                |
|  | 150 mg/kg SC, IM q24h × 5 days (administer q48h with long-acting preparation) <sup><a href="#">702</a></sup>                   | Pigeons                                |
|  | 150 mg/kg PO, IV <sup><a href="#">750</a></sup>                                                                                | Pigeons/PD; <i>Streptococcus bovis</i> |
|  | 150-175 mg/kg PO q12h <sup><a href="#">147</a>,<a href="#">409</a></sup>                                                       | Passerines (towhees), psittacines      |
|  | 150-175 mg/kg PO q4-8h <sup><a href="#">696</a>,<a href="#">812</a></sup>                                                      | Pigeons, psittacines                   |
|  | 65 mg/L drinking water <sup><a href="#">810</a></sup>                                                                          | Ratites                                |
|  | 200-400 mg/L drinking water <sup><a href="#">312</a></sup>                                                                     | Canaries/aviary use                    |
|  | 330 mg/L drinking water, <sup><a href="#">63</a></sup> provide on alternate days × 3 treatments <sup><a href="#">119</a></sup> | Waterfowl                              |
|  | 500-800 mg/L drinking water <sup><a href="#">320</a></sup>                                                                     | Pigeons                                |
|  | 1500 mg/L drinking water × 5 days <sup><a href="#">750</a></sup>                                                               | Pigeons/ <i>S. bovis</i>               |
|  | 1500-4500 mg/L drinking water <sup><a href="#">147</a></sup>                                                                   | Psittacines                            |
|  | 300-500 mg/kg soft                                                                                                             | Canaries/aviary use                    |

|                       |                                                                |                                                                                                                                                                                                                                                     |
|-----------------------|----------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                       | feed <sup><a href="#">312</a></sup>                            |                                                                                                                                                                                                                                                     |
|                       | 600 mg/kg soft feed <sup><a href="#">147</a></sup>             | Psittacines                                                                                                                                                                                                                                         |
| Ampicillin sodium     | 50 mg/kg IM q6-8h <sup><a href="#">218</a></sup>               | Amazon parrots/PD; localized infections                                                                                                                                                                                                             |
|                       | 100 mg/kg IM q4h <sup><a href="#">218</a></sup>                | Amazon parrots/PD                                                                                                                                                                                                                                   |
|                       | 150 mg/kg q12-24h IM <sup><a href="#">195,199</a></sup>        | Pigeons/PD                                                                                                                                                                                                                                          |
|                       | 150 mg/kg IM q12-24h <sup><a href="#">198</a></sup>            | Passerines, soft bills                                                                                                                                                                                                                              |
|                       | 150-200 mg/kg PO q8-12h <sup><a href="#">218</a></sup>         | Amazon parrots/PD; therapeutic levels not achieved in blue-naped Amazons at this dosage                                                                                                                                                             |
|                       | 174 mg/kg PO q24h <sup><a href="#">181</a></sup>               | Pigeons/PD; <i>Streptococcus bovis</i>                                                                                                                                                                                                              |
|                       | 528 mg/L drinking water <sup><a href="#">181</a></sup>         | Pigeons/PD; <i>S. bovis</i>                                                                                                                                                                                                                         |
| Ampicillin trihydrate | —                                                              | Broad-spectrum bactericidal penicillin antibiotic; minimal activity for common gram-negative infections of birds; poor gastrointestinal absorption; may be useful for treating sensitive gastrointestinal infections <sup><a href="#">702</a></sup> |
|                       | 4-7 mg/kg SC, IM q8h <sup><a href="#">810</a></sup>            | Ratites (excluding emus)                                                                                                                                                                                                                            |
|                       | 11-15 mg/kg PO q8h <sup><a href="#">810</a></sup>              | Ratites                                                                                                                                                                                                                                             |
|                       | 15 mg/kg IM q12h <sup><a href="#">100</a></sup>                | Raptors/PD                                                                                                                                                                                                                                          |
|                       | 15-20 mg/kg SC, IM q12h <sup><a href="#">100,384,511</a></sup> | Emus, cranes (PD)                                                                                                                                                                                                                                   |
|                       | 25 mg/kg PO q12-24h <sup><a href="#">195,199</a></sup>         | Pigeons/PD                                                                                                                                                                                                                                          |
|                       | 55-110 mg/kg IM q8-12h <sup><a href="#">321</a></sup>          | Poultry                                                                                                                                                                                                                                             |
|                       | 100 mg/kg PO q12-24h <sup><a href="#">195,199</a></sup>        | Pigeon/PD                                                                                                                                                                                                                                           |
|                       | 100 mg/kg IM q12h <sup><a href="#">577</a></sup>               | Cranes                                                                                                                                                                                                                                              |
|                       | 100 mg/kg IM q4h <sup><a href="#">134,702,812</a></sup>        | Most species, including psittacines                                                                                                                                                                                                                 |
|                       | 100-200 mg/kg PO q6-8h <sup><a href="#">702,812</a></sup>      | Psittacines                                                                                                                                                                                                                                         |
|                       | 155 mg/kg IM q12-24h <sup><a href="#">205</a></sup>            | Pigeons/PD; amoxicillin preferred over ampicillin for IM use in pigeons                                                                                                                                                                             |
|                       |                                                                |                                                                                                                                                                                                                                                     |

|                                                                                               |                                                                                               |                                                                                                                                                                               |
|-----------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                                                                                               | 170 mg/L drinking water <sup><a href="#">102</a></sup>                                        | Game birds                                                                                                                                                                    |
|                                                                                               | 1000 mg/L drinking water <sup><a href="#">671</a></sup>                                       | Galliformes/flock use                                                                                                                                                         |
|                                                                                               | 1000-2000 mg/L drinking water <sup><a href="#">312</a></sup>                                  | Canaries/aviary use                                                                                                                                                           |
|                                                                                               | 2000-3000 mg/kg soft feed <sup><a href="#">312</a></sup>                                      | Canaries/aviary use                                                                                                                                                           |
| Apramycin (Apralan, Elanco)                                                                   | —                                                                                             | Aminoglycoside; nephrotoxic; therapeutic levels not achieved in Japanese quail at 50 mg/kg IV; <sup><a href="#">444</a></sup> not available in the United States              |
|                                                                                               | 250-500 mg/L drinking water <sup><a href="#">102</a></sup>                                    | Gamebirds                                                                                                                                                                     |
|                                                                                               | 500 mg powder/L drinking water <sup><a href="#">64,787</a></sup>                              | Psittacines, chickens/ <i>Pseudomonas</i>                                                                                                                                     |
| Arsanilic acid (sodium arsanilate or P-amino-benzenearsonic acid) (Pro-Gen, Vétoquinol)       | 100 mg/kg feed <sup><a href="#">787</a></sup>                                                 | Poultry/do not use in ducks and geese                                                                                                                                         |
| Azithromycin (Zithromax, Pfizer)                                                              | —                                                                                             | Newer-generation macrolide indicated for intracellular infections including <i>Toxoplasma</i> , <i>Plasmodium</i> , <i>Chlamydophila</i> , and <i>Cryptosporidium</i>         |
|                                                                                               | 10-20 mg/kg PO q48h × 5 treatments <sup><a href="#">117</a></sup>                             | Blue and gold macaws/PD; nonintracellular infections                                                                                                                          |
|                                                                                               | 40 mg/kg PO q24h × 30 days <sup><a href="#">117</a></sup>                                     | Blue and gold macaws/PD; intracellular infections (i.e., <i>Chlamydophila</i> )                                                                                               |
|                                                                                               | 40 mg/kg PO q48h × 21 days <sup><a href="#">305</a></sup>                                     | Cockatiels/PD; <i>Chlamydophila</i>                                                                                                                                           |
|                                                                                               | 43-45 mg/kg PO q24h <sup><a href="#">200,695</a></sup>                                        | Most species including psittacines, passerines/intracellular infections including <i>Mycobacterium</i> ; used with ethambutol and rifabutin (see <a href="#">Table 5-45</a> ) |
|                                                                                               | 50-80 mg/kg PO q24h × 3 days on, off 4 days, repeat up to 3 wk <sup><a href="#">672</a></sup> | Most species/ <i>Mycoplasma</i> ; do not use if hepatic or renal disease; can mix with lactulose (stable refrigerated for 3-4 wk)                                             |
| Bacitracin methylene disalicylate (Solutracin 200, A.L. Laboratories; BMD Soluble, Alphaarma) | 50-400 mg/L drinking water <sup><a href="#">384,810</a></sup>                                 | Ratites/ <i>Clostridium perfringens</i> ; prepare daily                                                                                                                       |
|                                                                                               | 220 mg/L <sup><a href="#">119</a></sup>                                                       | Quail/ <i>Clostridium perfringens</i>                                                                                                                                         |
|                                                                                               | 55-220 mg/kg feed <sup><a href="#">511</a></sup>                                              | Quail                                                                                                                                                                         |

|                                                               |                                                                                |                                                                                                                                                                                                            |
|---------------------------------------------------------------|--------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                                                               | 100-500 mg/kg feed <sup><a href="#">102</a></sup>                              | Ostriches <3 mo of age                                                                                                                                                                                     |
| Carbenicillin (Geocillin, Roerig; Pyopen, SmithKline Beechum) | —                                                                              | Extended-spectrum penicillin effective against gram-negative bacteria, especially <i>Pseudomonas</i> , <i>Proteus</i> <sup><a href="#">702</a></sup>                                                       |
|                                                               | 11-15 mg/kg IV q8h <sup><a href="#">810</a></sup>                              | Ratites                                                                                                                                                                                                    |
|                                                               | 100 mg/kg PO q12h <sup><a href="#">518</a></sup>                               | Most species                                                                                                                                                                                               |
|                                                               | 100 mg/kg IM q8h <sup><a href="#">47</a></sup>                                 | Most species                                                                                                                                                                                               |
|                                                               | 100 mg/kg IT q24h <sup><a href="#">134</a></sup>                               | Most species/ <i>Pseudomonas</i> respiratory infections                                                                                                                                                    |
|                                                               | 100-200 mg/kg IM, IV q6-12h <sup><a href="#">113,200,323,672,702,812</a></sup> | Most species, including psittacines, passerines, soft bills, pigeons, cranes, raptors                                                                                                                      |
|                                                               | 250 mg/kg IM q12h <sup><a href="#">653</a></sup>                               | Raptors                                                                                                                                                                                                    |
|                                                               | 1058 mg/L drinking water <sup><a href="#">518</a></sup>                        | Most species                                                                                                                                                                                               |
| Cefadroxil                                                    | —                                                                              | First-generation cephalosporin                                                                                                                                                                             |
|                                                               | 20 mg/kg PO q12h <sup><a href="#">841</a></sup>                                | Ratites                                                                                                                                                                                                    |
|                                                               | 100 mg/kg PO q12h × 7 days <sup><a href="#">320,692</a></sup>                  | Most psittacines, pigeons/14-21 day therapy may be indicated for severe or deep pyodermas                                                                                                                  |
| Cefazolin                                                     | —                                                                              | First-generation cephalosporin                                                                                                                                                                             |
|                                                               | 22-110 mg/kg IM q8-12h <sup><a href="#">321</a></sup>                          | Poultry                                                                                                                                                                                                    |
|                                                               | 25-30 mg/kg IM, IV q8h <sup><a href="#">111</a></sup>                          | Cranes                                                                                                                                                                                                     |
|                                                               | 25-50 mg/kg IM, IV q12h <sup><a href="#">672</a></sup>                         | Most species                                                                                                                                                                                               |
|                                                               | 50-75 mg/kg IM q12h <sup><a href="#">692</a></sup>                             | Most species                                                                                                                                                                                               |
|                                                               | 50-100 mg/kg PO, IM q12h <sup><a href="#">622</a></sup>                        | Raptors                                                                                                                                                                                                    |
| Cefotaxime (Claforan, Hoechst-Roussel)                        | —                                                                              | Third-generation cephalosporin with broad-spectrum activity for many gram-positive and gram-negative pathogens; <sup><a href="#">702</a></sup> penetrates cerebrospinal fluid <sup><a href="#">5</a></sup> |
|                                                               | 25 mg/kg IM q8h <sup><a href="#">813</a></sup>                                 | Ratites/young birds                                                                                                                                                                                        |
|                                                               | 50-100 mg/kg IM q8-12h <sup><a href="#">577</a></sup>                          | Cranes                                                                                                                                                                                                     |
|                                                               | 75-100 mg/kg IM                                                                | Raptors                                                                                                                                                                                                    |

|                              |                                                                        |                                                                                                                                                                                                             |
|------------------------------|------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                              | q12h <sup><a href="#">363</a></sup>                                    |                                                                                                                                                                                                             |
|                              | 75-100 mg/kg IM, IV<br>q4-8h <sup><a href="#">50,200,702,812</a></sup> | Most species, including soft bills, psittacines, passerines                                                                                                                                                 |
|                              | 100 mg/kg IM q8-12h <sup><a href="#">320</a></sup>                     | Pigeons                                                                                                                                                                                                     |
| Cefovecin (Convenia, Pfizer) | 10 mg/kg SC, IM, IV<br>q1h <sup><a href="#">718,804</a></sup>          | Pigeons, chickens/PD; not recommended for use in birds due to short ½ life; cannot be used q14d as in dogs and cats                                                                                         |
| Cefoxitin                    | —                                                                      | Second-generation cephalosporin with a wide range of activity against many gram-positive and gram-negative bacteria                                                                                         |
|                              | 50-75 mg/kg IM, IV q6-8h <sup><a href="#">200,813</a></sup>            | Most species, including soft bills                                                                                                                                                                          |
|                              | 50-100 mg/kg IM, IV<br>q6-12h <sup><a href="#">672,812</a></sup>       | Psittacines                                                                                                                                                                                                 |
| Cefquinome                   | 5 mg/kg IM q24h <sup><a href="#">865</a></sup>                         | Ducks/broad-spectrum cephalosporin; no effect PO                                                                                                                                                            |
| Ceftazidime                  | —                                                                      | Broad-spectrum third-generation cephalosporin; penetrates central nervous system <sup><a href="#">5</a></sup>                                                                                               |
|                              | 50-100 mg/kg IM, IV<br>q4-8h <sup><a href="#">244,696</a></sup>        | Most species                                                                                                                                                                                                |
| Ceftiofur (Naxcel, Pfizer)   | —                                                                      | Broad-spectrum third-generation cephalosporin with activity against <i>Pasteurella</i> , <i>E. coli</i> , <i>Streptococcus</i> , <i>Staphylococcus</i> , and <i>Salmonella</i> <sup><a href="#">5</a></sup> |
|                              | 0.16 mg/chick SC<br>q24h <sup><a href="#">796</a></sup>                | Chickens (chicks)/PD; treatment of early mortality associated with <i>E. coli</i>                                                                                                                           |
|                              | 0.17-0.5 mg/poult SC<br>q24h <sup><a href="#">796</a></sup>            | Turkeys                                                                                                                                                                                                     |
|                              | 2-4 mg/kg SC q24h <sup><a href="#">128</a></sup>                       | Ducks                                                                                                                                                                                                       |
|                              | 2.8-5.8 mg/kg SC<br>q24h <sup><a href="#">796</a></sup>                | Turkeys (poults)/PD; treatment of early mortality associated with <i>E. coli</i>                                                                                                                            |
|                              | 10 mg/kg IM q8-12h <sup><a href="#">796</a></sup>                      | Orange-winged Amazon parrots/PD                                                                                                                                                                             |
|                              | 10 mg/kg IM q4h <sup><a href="#">796</a></sup>                         | Cockatiels/PD; higher doses may be required for resistant infections                                                                                                                                        |
|                              | 10 mg/kg IM q72h <sup><a href="#">b</a></sup>                          | Guineafowl/PD                                                                                                                                                                                               |
|                              | 10-20 mg/kg IM<br>q12h <sup><a href="#">1,841</a></sup>                | Ratites                                                                                                                                                                                                     |
|                              |                                                                        |                                                                                                                                                                                                             |



|             |                                                                            |                                                                                                                                                                                                                                   |
|-------------|----------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|             | 50 mg/kg IM q12h <sup>1</sup><br>30-100 mg/kg q4-8h <sup>200,702,812</sup> | Ostrich chicks.<br>Most species, including psittacines and passerines                                                                                                                                                             |
| Ceftriaxone | —                                                                          | Third-generation cephalosporin; effective against gram-positive and gram-negative bacteria including some activity against <i>Pseudomonas</i> <sup>702</sup>                                                                      |
|             | 75-100 mg/kg IM q4-8h <sup>239,702,812</sup>                               | Most species                                                                                                                                                                                                                      |
|             | 100 mg/kg IM q4h <sup>405</sup>                                            | Chickens/PD                                                                                                                                                                                                                       |
| Cephalexin  | —                                                                          | First-generation cephalosporin; active against many gram-positive and gram-negative bacteria, including <i>E. coli</i> and <i>Proteus</i> , but not <i>Pseudomonas</i> ; useful for <i>Staphylococcus dermatitis</i> <sup>5</sup> |
|             | 15-22 mg/kg PO q8h <sup>810</sup>                                          | Ratites (excluding emus)                                                                                                                                                                                                          |
|             | 35-50 mg/kg PO, IM q6-8h <sup>99,106,363,577</sup>                         | Pigeons, emus, cranes, raptors, psittacines >500 g/dose psittacines q6h                                                                                                                                                           |
|             | 35-50 mg/kg IM q2-3h <sup>99,147</sup>                                     | Quail, ducks (PD), psittacines <500 g                                                                                                                                                                                             |
|             | 40-100 mg/kg PO, IM q6-8h <sup>47,63,200,702,812</sup>                     | Most species, including raptors, psittacines, passerines                                                                                                                                                                          |
|             | 50 mg/kg PO q6h × 3-5 days <sup>102,534</sup>                              | Raptors, pigeons                                                                                                                                                                                                                  |
|             | 55-110 mg/kg PO q12h <sup>321</sup>                                        | Poultry/ <i>Mycoplasma</i> , <i>Haemophilus</i>                                                                                                                                                                                   |
|             | 100 mg/kg PO q8-12h <sup>320</sup>                                         | Pigeons/14-21 day therapy may be indicated for severe or deep pyodermas                                                                                                                                                           |
|             | 100 mg/kg PO q4-6h <sup>99</sup>                                           | Pigeons, emus, cranes/PD                                                                                                                                                                                                          |
| Cephalothin | —                                                                          | First-generation cephalosporin                                                                                                                                                                                                    |
|             | 30-40 mg/kg IM, IV q6h <sup>810</sup>                                      | Ratites (excluding emus)                                                                                                                                                                                                          |
|             | 100 mg/kg IM q8-12h <sup>363</sup>                                         | Raptors                                                                                                                                                                                                                           |
|             | 100 mg/kg IM, IV q6-8h <sup>134,810</sup>                                  | Most species, including psittacines, ratites                                                                                                                                                                                      |
|             | 100 mg/kg IM q6h <sup>99</sup>                                             | Pigeons, emus, cranes/PD                                                                                                                                                                                                          |
|             | 100 mg/kg IM, IV q2-6h <sup>200</sup>                                      | Passerines                                                                                                                                                                                                                        |
|             | 100 mg/kg IM q2-3h <sup>99</sup>                                           | Quail, ducks/PD                                                                                                                                                                                                                   |

|                                             |                                                    |                                                                                                                                                                                                                                                                                                                                                                                                                  |
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| Cephradine                                  | —                                                  | First-generation cephalosporin                                                                                                                                                                                                                                                                                                                                                                                   |
|                                             | 35-50 mg/kg PO q4-6h <sup>671</sup>                | Most species/14-21 day therapy may be indicated for severe or deep pyodermas                                                                                                                                                                                                                                                                                                                                     |
|                                             | 100 mg/kg PO q4-6h <sup>671</sup>                  | Pigeons, emus, cranes                                                                                                                                                                                                                                                                                                                                                                                            |
| Chloramphenicol palmitate (oral suspension) | —                                                  | Not for use in food animals; <sup>332</sup> wear gloves; bone marrow suppression (irreversible aplastic anemia in humans); potential nephrotoxicity; bacteriostatic activity; <sup>614</sup> mainly excreted after biotransformation; because large differences in pharmacokinetics exist between birds and mammals, and even between avian species, extrapolation between species is ill-advised <sup>204</sup> |
|                                             | 25 mg/kg PO q8h × 5 days <sup>102</sup>            | Pigeons                                                                                                                                                                                                                                                                                                                                                                                                          |
|                                             | 30-50 mg/kg PO q6-8h <sup>702,811,812</sup>        | Psittacines, including budgerigars                                                                                                                                                                                                                                                                                                                                                                               |
|                                             | 35-50 mg/kg PO q8h × 3 days <sup>810</sup>         | Ratites                                                                                                                                                                                                                                                                                                                                                                                                          |
|                                             | 50 mg/kg PO q6-12h <sup>16,363,673</sup>           | Raptors, galliformes (turkeys)                                                                                                                                                                                                                                                                                                                                                                                   |
|                                             | 50-100 mg/kg PO q6-12h <sup>45,200</sup>           | Most species, including passerines                                                                                                                                                                                                                                                                                                                                                                               |
|                                             | 250 mg/kg PO q6h <sup>320</sup>                    | Pigeons                                                                                                                                                                                                                                                                                                                                                                                                          |
|                                             | 100-200 mg/L drinking water <sup>672</sup>         | Canaries                                                                                                                                                                                                                                                                                                                                                                                                         |
| Chloramphenicol succinate                   | 22 mg/kg IM, IV q3h <sup>182</sup>                 | Ducks (PD), raptors                                                                                                                                                                                                                                                                                                                                                                                              |
|                                             | 30 mg/kg IM q8h × 3-5 days <sup>259</sup>          | Raptors                                                                                                                                                                                                                                                                                                                                                                                                          |
|                                             | 35-50 mg/kg SC, IM, IV q8h × 3 days <sup>810</sup> | Ratites                                                                                                                                                                                                                                                                                                                                                                                                          |
|                                             | 50 mg/kg IM q6h <sup>129</sup>                     | Macaws, conures (PD)                                                                                                                                                                                                                                                                                                                                                                                             |
|                                             | 50 mg/kg IM q8-12h <sup>200</sup>                  | Passerines                                                                                                                                                                                                                                                                                                                                                                                                       |
|                                             | 50 mg/kg IM q24h <sup>129</sup>                    | Peafowl, eagles (PD)                                                                                                                                                                                                                                                                                                                                                                                             |
|                                             | 50 mg/kg IM, IV q6-12h <sup>129,200,702</sup>      | Most species, including budgerigars, passerines, pigeons, raptors, chickens, turkeys, geese (PD), <sup>129</sup> ducks                                                                                                                                                                                                                                                                                           |
|                                             | 50-80 mg/kg IM q12-24h <sup>200</sup>              | Passerines                                                                                                                                                                                                                                                                                                                                                                                                       |

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|                                                         | 60-100 mg/kg IM q8h <sup><a href="#">323</a></sup>                            | Pigeons                                                                                                                                                                                                                                                                   |
|                                                         | 79 mg/kg IM q12h <sup><a href="#">129</a></sup>                               | Turkeys/PD                                                                                                                                                                                                                                                                |
|                                                         | 100 mg/kg SC q8h <sup><a href="#">577</a></sup>                               | Cranes                                                                                                                                                                                                                                                                    |
|                                                         | 100 mg/kg IM q6h <sup><a href="#">200</a></sup>                               | Passerines                                                                                                                                                                                                                                                                |
|                                                         | 200 mg/kg IM q12h × 5 days <sup><a href="#">372</a></sup>                     | Budgerigars/PD                                                                                                                                                                                                                                                            |
| Chlorhexidine                                           | 2.6-7.9 mL of 2% solution/L drinking water <sup><a href="#">673,779</a></sup> | Most species/bacterial infection; topical application may be fatal to nun and parrot finches <sup><a href="#">672</a></sup>                                                                                                                                               |
|                                                         | 7.9 mL/L water <sup><a href="#">810</a></sup>                                 | Ratites/egg disinfectant spray at 104-108°F (40-42°C)                                                                                                                                                                                                                     |
| Chlorine (Na hypochlorite)                              | 5 mg/L drinking water <sup><a href="#">692</a></sup>                          | Water disinfectant; 0.1 mL of 5.25% bleach/L approximates this concentration                                                                                                                                                                                              |
| Chlortetracycline (Aureomycin Soluble Powder, Cyanamid) | —                                                                             | Broad-spectrum activity against a wide range of gram-positive and gram-negative bacteria; flock treatment of <i>Chlamydophila</i> , although doxycycline is preferred; <sup><a href="#">702</a></sup> outdated tetracycline is nephrotoxic <sup><a href="#">270</a></sup> |
|                                                         | 6-10 mg/kg IM q24h <sup><a href="#">341</a></sup>                             | Raptors                                                                                                                                                                                                                                                                   |
|                                                         | 15-20 mg/kg PO q8h <sup><a href="#">810</a></sup>                             | Ratites                                                                                                                                                                                                                                                                   |
|                                                         | 40-50 mg/kg PO q8h (w/grit) or q12h (w/o grit)                                | Pigeons/PD                                                                                                                                                                                                                                                                |
|                                                         | 100 mg/kg PO q6h <sup><a href="#">147</a></sup>                               | Psittacines                                                                                                                                                                                                                                                               |
|                                                         | 250 mg/kg PO q24h <sup><a href="#">341</a></sup>                              | Raptors                                                                                                                                                                                                                                                                   |
|                                                         | 40-120 mg/L drinking water <sup><a href="#">102</a></sup>                     | Galliformes (game birds)                                                                                                                                                                                                                                                  |
|                                                         | 130-400 mg/L drinking water <sup><a href="#">320,702,808</a></sup>            | Pigeons                                                                                                                                                                                                                                                                   |
|                                                         | 500 mg/L drinking water or nectar <sup><a href="#">133,134</a></sup>          | Most species/prepare fresh q8-12h                                                                                                                                                                                                                                         |
|                                                         | 1000-1500 mg/L drinking water <sup><a href="#">147,197</a></sup>              | Canaries, psittacines/prophylaxis against <i>Chlamydophila</i>                                                                                                                                                                                                            |
|                                                         | 5000 mg/L drinking water × 45 days <sup><a href="#">147</a></sup>             | Psittacines/ <i>Chlamydophila</i>                                                                                                                                                                                                                                         |
|                                                         | 100 mg/kg feed <sup><a href="#">808</a></sup>                                 | Pigeons/ <i>Salmonella</i>                                                                                                                                                                                                                                                |

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|                              | 200-600 mg/kg feed <sup><a href="#">102</a></sup>                               | Galliformes                                                                                                                |
|                              | 300-400 mg/kg feed <sup><a href="#">119</a></sup>                               | Waterfowl/colibacillosis, <i>Chlamydophila</i> , <i>Salmonella</i>                                                         |
|                              | 500 mg/kg feed <sup><a href="#">199</a></sup>                                   | Budgerigars/ <i>Chlamydophila</i>                                                                                          |
|                              | 1000 mg/kg feed <sup><a href="#">63</a></sup>                                   | Waterfowl                                                                                                                  |
|                              | 1000-2000 mg/kg soft mixed feed × 45 days <sup><a href="#">64,197,198</a></sup> | Most psittacines, canaries                                                                                                 |
|                              | 2500 mg/kg feed <sup><a href="#">873</a></sup> and 2500 mg/L drinking water     | Chickens, turkeys/PD; simultaneous medication of feed and water required to reach therapeutic level                        |
|                              | 5000 mg/kg soft feed × 45 days <sup><a href="#">147</a></sup>                   | Psittacines/ <i>Chlamydophila</i>                                                                                          |
|                              | 0.5% pellets × 30-45 days <sup><a href="#">47,133,134,196</a></sup>             | Small psittacines/reduce calcium content of diet to 0.7%                                                                   |
|                              | 1% pellets × 30-45 days <sup><a href="#">196,242,252</a></sup>                  | Large psittacines/reduce calcium content of diet to 0.7%                                                                   |
| Ciprofloxacin (Cipro, Bayer) | —                                                                               | Broad-spectrum quinolone; not approved for use in food-producing birds in the United States <sup><a href="#">258</a></sup> |
|                              | 2 mg/kg IV <sup><a href="#">552</a></sup>                                       | Chicks/no toxic effects observed                                                                                           |
|                              | 3-6 mg/kg PO q12h <sup><a href="#">810</a></sup>                                | Ratites                                                                                                                    |
|                              | 5 mg/kg/day PO × 5 days <sup><a href="#">282</a></sup>                          | Chickens/PD                                                                                                                |
|                              | 5-20 mg/kg PO q12h × 5-7 days <sup><a href="#">693</a></sup>                    | Pigeons                                                                                                                    |
|                              | 10 mg/kg PO q12h × 7 days <sup><a href="#">2</a></sup>                          | Ostrich chicks                                                                                                             |
|                              | 10-20 mg/kg PO q12h <sup><a href="#">215,363</a></sup>                          | Raptors, chickens                                                                                                          |
|                              | 15-20 mg/kg PO, IM q12h <sup><a href="#">47,200,811,812</a></sup>               | Most species, including psittacines, passerines                                                                            |
|                              | 20-40 mg/kg PO, IV q12h <sup><a href="#">511,672</a></sup>                      | Most species, including psittacines, canaries, raptors                                                                     |
|                              | 50 mg/kg PO q12h <sup><a href="#">370</a></sup>                                 | Raptors/PD                                                                                                                 |
|                              | 80 mg/kg PO q24h <sup><a href="#">824</a></sup>                                 | Most species/ <i>Mycobacterium</i> ; use in combination with other agents (see <a href="#">Table 5-45</a> )                |
|                              | 250 mg/L drinking                                                               | Pigeons                                                                                                                    |

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|                                  | water × 5-10 days <sup>693</sup>                                |                                                                                                                                                                                                                   |
| Clarithromycin (Biaxin, Abbott)  | —                                                               | Broad-spectrum new generation macrolide; frequently used in combination with other drugs for mycobacteriosis (see <a href="#">Table 5-45</a> )                                                                    |
|                                  | 10 mg/kg PO q24h <sup>559</sup>                                 | Penguins                                                                                                                                                                                                          |
|                                  | 60 mg/kg q24h <sup>452</sup>                                    | Psittacines                                                                                                                                                                                                       |
|                                  | 85 mg/kg PO q24h <sup>695</sup>                                 | Most species/ <i>Mycobacterium</i> ; allometrically scaled                                                                                                                                                        |
| Clindamycin                      | —                                                               | Lincosamide; indicated for bone, joint, and tendon sheath infections; may be used for up to 12 wk without ill effects; <sup>702</sup> monitor kidney and liver with long-term use as well as for yeast overgrowth |
|                                  | 5.5 mg/kg PO q8h <sup>534</sup>                                 | Ostriches                                                                                                                                                                                                         |
|                                  | 12.5 mg/kg PO q12h <sup>313</sup>                               | Great horned owls/skin grafts; given in combination with enrofloxacin                                                                                                                                             |
|                                  | 25 mg/kg PO q8h <sup>242</sup>                                  | Psittacines, raptors                                                                                                                                                                                              |
|                                  | 50 mg/kg PO q8-12h <sup>244</sup>                               | Most species/7-10 day course recommended for raptors with osteomyelitis <sup>63</sup>                                                                                                                             |
|                                  | 100 mg/kg PO q24h × 3-5 days <sup>200,242,363,673,702,812</sup> | Most species, including psittacines, passerines, raptors, pigeons, quail/ <i>Clostridium</i>                                                                                                                      |
|                                  | 100 mg/kg PO q12h <sup>609</sup> × 7 days                       | Psittacines                                                                                                                                                                                                       |
|                                  | 150 mg/kg PO q24h <sup>302</sup>                                | Pigeons, raptors/osteomyelitis                                                                                                                                                                                    |
|                                  | 200 mg/L drinking water <sup>157</sup>                          | Pigeons                                                                                                                                                                                                           |
| Clofazimine (Lamprene, Novartis) | 1-5 mg/kg PO q24h × 3-12 mo <sup>63,64,702</sup>                | Psittacines, raptors/ <i>Mycobacterium</i> ; use in combination with other agents (see <a href="#">Table 5-45</a> )                                                                                               |
|                                  | 6 mg/kg PO q12h <sup>695,824</sup>                              | Most species/ <i>Mycobacterium</i> ; use in combination with other agents (see <a href="#">Table 5-45</a> )                                                                                                       |
|                                  | 6-12 mg/kg PO q24h <sup>200,452</sup>                           | Passerines/ <i>Mycobacterium</i> ; use in combination with other agents (see <a href="#">Table 5-45</a> )                                                                                                         |
| Cloxacillin                      | —                                                               | Penicillin effective against many gram-positive organisms; recommended in the treatment of pododermatitis <sup>702</sup>                                                                                          |

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|                                      | 100-200 mg/kg IM q24h <sup><a href="#">534</a></sup>                      | Most species                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
|                                      | 250 mg/kg PO q24h <sup><a href="#">500</a></sup>                          | Most species                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
|                                      | 250 mg/kg PO q12h × 7-10 days <sup><a href="#">63</a></sup>               | Raptors                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
| Cycloserine (Seromycin, Lilly)       | 5 mg/kg PO q12-24h × 3-12 mo <sup><a href="#">63,702</a></sup>            | Raptors/ <i>Mycobacterium</i> ; use in combination with other agents (see <a href="#">Table 5-45</a> )                                                                                                                                                                                                                                                                                                                                                                        |
| Danofloxacin mesylate (A180, Pfizer) | —                                                                         | Fluoroquinolone; not approved for use in food-producing birds in the United States <sup><a href="#">258</a></sup>                                                                                                                                                                                                                                                                                                                                                             |
|                                      | 5 mg/kg PO, IM, IV <sup><a href="#">215,521,787</a></sup>                 | Hyacinth macaws, chickens (PD)/higher therapeutic efficacy of water medication for enrofloxacin compared to danofloxacin can be expected when given at 5 mg/kg <sup><a href="#">422</a></sup>                                                                                                                                                                                                                                                                                 |
|                                      | 50 mg/L in drinking water × 3 days <sup><a href="#">525,672,788</a></sup> | Chicken chicks/ <i>Mycoplasma</i>                                                                                                                                                                                                                                                                                                                                                                                                                                             |
| Doxycycline (Vibramycin, Pfizer)     | —                                                                         | Drug of choice for <i>Chlamydophila</i> , <i>Mycoplasma</i> ; products or foods containing Al, Ca, Mg, and Fe reduce or alter absorption although doxycycline has a relatively low affinity for calcium binding; <sup><a href="#">206</a></sup> outdated tetracycline is nephrotoxic; <sup><a href="#">270</a></sup> 12.5-25 mg/kg PO q12-24h resulted in elevations in AST and serum bile acids as well as hepatocellular damage in lorikeets <sup><a href="#">875</a></sup> |
|                                      | 2-3.5 mg/kg PO q12h <sup><a href="#">810</a></sup>                        | Ratites                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
|                                      | 7.5-8 mg/kg PO q12-24h <sup><a href="#">195,672</a></sup>                 | Passerines, nectar feeders, pigeons/PD; administer without grit <sup><a href="#">197</a></sup>                                                                                                                                                                                                                                                                                                                                                                                |
|                                      | 8-25 mg/kg PO q12h <sup><a href="#">119</a></sup>                         | Waterfowl                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
|                                      | 10-20 mg/kg PO q24h × 3-5 days <sup><a href="#">102</a></sup>             | Pigeons                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
|                                      | 25 mg/kg (w/grit) PO q12h <sup><a href="#">878</a></sup>                  | Pigeons/PD                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
|                                      | 25 mg/kg PO q12h <sup><a href="#">397</a></sup>                           | Psittacines, raptors/some gram-negative bacterial infections and possibly <i>Leucocytozoon</i>                                                                                                                                                                                                                                                                                                                                                                                |
|                                      | 25-50 mg/kg PO q12-                                                       | Most species, including parrots (African grey parrots, Amazon parrots, cockatoos, macaws) and pigeons/may cause                                                                                                                                                                                                                                                                                                                                                               |

|  |                                                                                                                                    |                                                                                                                                                                                               |
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|  | 24h <sup><a href="#">198,242,363,811,812</a></sup>                                                                                 | regurgitation; use low end of dose range for macaws and cockatoos                                                                                                                             |
|  | 35 mg/kg PO q24h × 21 days <sup><a href="#">305</a></sup>                                                                          | Cockatiels/PD; <i>Chlamydophila</i>                                                                                                                                                           |
|  | 40 mg/kg PO q24h <sup><a href="#">181</a></sup>                                                                                    | Pigeons/PD; <i>Streptococcus bovis</i>                                                                                                                                                        |
|  | 50 mg/kg PO q12h <sup><a href="#">63</a></sup>                                                                                     | Waterfowl                                                                                                                                                                                     |
|  | 100 mg/L drinking water <sup><a href="#">221</a></sup>                                                                             | Chickens/PD                                                                                                                                                                                   |
|  | 130 mg/L drinking water <sup><a href="#">147</a></sup>                                                                             | Psittacines                                                                                                                                                                                   |
|  | 200 mg/L drinking water <sup><a href="#">222</a></sup>                                                                             | Pigeons                                                                                                                                                                                       |
|  | 250 mg/L drinking water <sup><a href="#">197</a></sup>                                                                             | Canaries                                                                                                                                                                                      |
|  | 265-525 mg/L drinking water <sup><a href="#">321</a></sup>                                                                         | Poultry/ <i>Mycoplasma</i> , <i>Haemophilus</i> ; can use in combination with tylosin                                                                                                         |
|  | 280 mg/L drinking water <sup><a href="#">626</a></sup>                                                                             | Cockatiels/see <a href="#">Table 5-41</a> for recipe                                                                                                                                          |
|  | 400 mg/L drinking water <sup><a href="#">225</a></sup>                                                                             | Cockatiels/PD; spiral bacteria                                                                                                                                                                |
|  | 500 mg/L drinking water <sup><a href="#">147,181</a></sup>                                                                         | Psittacines, pigeons/PD; <i>S. bovis</i>                                                                                                                                                      |
|  | 500 mg/L drinking water <sup><a href="#">591</a></sup>                                                                             | Fruit doves/PD; erratic drug concentrations (while most birds reached or exceeded therapeutic drug levels, some birds did not)                                                                |
|  | 800 mg/L drinking water (mix the contents of 16 x 100 mg capsules with 2 L water; make fresh daily) <sup><a href="#">249</a></sup> | African grey parrots, Goffin's cockatoos/PD; protect solution from exposure to light                                                                                                          |
|  | 250-300 mg/kg seed <sup><a href="#">63,241</a></sup>                                                                               | Waterfowl, budgerigars (PD)                                                                                                                                                                   |
|  | 500 mg/kg wet weight seeds <sup><a href="#">626</a></sup>                                                                          | Cockatiels/PD; see <a href="#">Table 5-41</a> for recipe                                                                                                                                      |
|  | 1000 mg/kg feed <sup><a href="#">197,198,630</a></sup>                                                                             | Large psittacines on dehulled seed (PD), macaws on corn (PD), canaries, large psittacines on soft feed (10 mg/mL syrup mixed into 29% kidney beans, 29% canned corn, 29% cooked rice, 13% dry |



|                                                                    |                                                          |                                                                                                                                                                                                                                                                                                                                 |
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|                                                                    |                                                          | oatmeal cereal)                                                                                                                                                                                                                                                                                                                 |
| Doxycycline (Vibravenös, Pfizer)                                   | —                                                        | Not available in the United States without written permission by Food and Drug Administration                                                                                                                                                                                                                                   |
|                                                                    | 25-50 mg/kg IM q5-7d × 5-7 treatments <sup>696,811</sup> | Psittacines                                                                                                                                                                                                                                                                                                                     |
|                                                                    | 60-100 mg/kg SC, IM q5-7d <sup>197</sup>                 | Psittacines, pigeons/PD                                                                                                                                                                                                                                                                                                         |
|                                                                    | 75 mg/kg IM q7d × 4-6 wk <sup>50,63</sup>                | Macaws, waterfowl                                                                                                                                                                                                                                                                                                               |
|                                                                    | 75-100 mg/kg IM q5-7d × 4-6 wk <sup>50,696,811</sup>     | Psittacines, including macaws, budgerigars                                                                                                                                                                                                                                                                                      |
|                                                                    | 100 mg/kg SC, IM q5-7d × 7 doses <sup>300</sup>          | Houbara bustards/PD; <i>Chlamydophila</i>                                                                                                                                                                                                                                                                                       |
| Doxycycline (Pharmacist-compounded micronized doxycycline hyclate) | 75-100 mg/kg IM q7d <sup>696</sup>                       | Cockatoos/anecdotal reports of sudden death with compounded product; inadequate drug levels achieved in cockatiels at 100 mg/kg IM q10d; <sup>626</sup> adequate drug levels achieved with 100 mg/kg given IM in cockatoos, Amazon parrots and SC in African grey parrots, but severe soft tissue reactions seen <sup>246</sup> |
| Doxycycline hyclate (Vibramycin injection, Pfizer)                 | —                                                        | Cardiovascular collapse associated with the propylene glycol carrier can occur after rapid IV injection <sup>270</sup>                                                                                                                                                                                                          |
|                                                                    | 25-50 mg/kg slow bolus IV q24h × 3 days <sup>696</sup>   | Psittacines                                                                                                                                                                                                                                                                                                                     |
|                                                                    | 75-100 mg/kg SC, IM q5-7d <sup>195</sup>                 | Pigeons/PD                                                                                                                                                                                                                                                                                                                      |
| Doxycycline (Doxirobe gel, Pharmacia)                              | Topical <sup>761</sup>                                   | Most species/apply to beak or pododermatitis lesions; use in conjunction with debridement; antibiotic is released for 28 days                                                                                                                                                                                                   |
| Enrofloxacin (Baytril, Bayer)                                      | —                                                        | Broad-spectrum quinolone, <sup>258</sup> compounds containing Ca, Al, Fe, Mg, Zn interfere with absorption                                                                                                                                                                                                                      |
|                                                                    |                                                          | Administration may be associated with emesis; <sup>702</sup> given PO, the IM formulation produces therapeutic plasma concentration; <sup>363</sup> IM formulation is extremely alkaline (painful) and should not be given repeatedly; best to avoid IV                                                                         |



|  |                                                           |                                                                                                                                                                                                                                                                                                  |
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|  |                                                           | use in birds; fluoroquinolones may be used in PMMA beads with success <sup>211</sup>                                                                                                                                                                                                             |
|  |                                                           | Joint deformities reported in squab chondrocytes with 200-800 mg/L drinking water; <sup>432</sup> however enrofloxacin has been commonly used at the recommended dosages without reports of adverse effects; <sup>250,672</sup> no detected effect on cartilage in day-old chicks <sup>606</sup> |
|  |                                                           | Administration of the total daily dose to chickens over 2-4 hr (pulse dosing) has been recommended by some <sup>765</sup>                                                                                                                                                                        |
|  | 1.5-2.5 mg/kg PO, SC q12h <sup>810</sup>                  | Ratites                                                                                                                                                                                                                                                                                          |
|  | 2.2 mg/kg IV q12h <sup>345</sup>                          | Emus/PD                                                                                                                                                                                                                                                                                          |
|  | 5 mg/kg SC, IM q12h <sup>811</sup>                        | Cockatiels                                                                                                                                                                                                                                                                                       |
|  | 5 mg/kg PO, IM q12-24h <sup>811</sup>                     | African grey parrots                                                                                                                                                                                                                                                                             |
|  | 5 mg/kg IM q12h × 2 days <sup>810</sup>                   | Ratites                                                                                                                                                                                                                                                                                          |
|  | 5 mg/kg/day PO × 5 days <sup>282</sup>                    | Chickens/PD; accumulates in eggs                                                                                                                                                                                                                                                                 |
|  | 5-10 mg/kg SC, IM q24h <sup>197,199</sup>                 | African grey parrots                                                                                                                                                                                                                                                                             |
|  | 5-10 mg/kg PO q8h                                         | Passerines, pigeons (PD)                                                                                                                                                                                                                                                                         |
|  | 5-15 mg/kg PO, SC, IM q12h <sup>323,363,696,702,812</sup> | Raptors, psittacines, pigeons/drug of choice for <i>Salmonella typhimurium</i>                                                                                                                                                                                                                   |
|  | 5-20 mg/kg PO q12-24h × 5-10 days <sup>102,811</sup>      | Pigeons                                                                                                                                                                                                                                                                                          |
|  | 10 mg/kg PO q12h <sup>113</sup>                           | Cockatiels                                                                                                                                                                                                                                                                                       |
|  | 10 mg/kg PO q12h × 4 days <sup>25</sup>                   | Chickens/PD; high efficacy for intestinal salmonellosis                                                                                                                                                                                                                                          |
|  | 10-15 mg/kg PO, IM q12h × 5-7 days <sup>702</sup>         | Raptors, waterfowl including Muscovy, Pekin ducklings/ <i>Riemerella (Pasteurella)</i>                                                                                                                                                                                                           |
|  | 10-20 mg/kg PO q24h <sup>197,200</sup>                    | Passerines, psittacines, pigeons (PD)                                                                                                                                                                                                                                                            |
|  | 15 mg/kg PO q24h <sup>609</sup>                           | Psittacines                                                                                                                                                                                                                                                                                      |
|  | 15 mg/kg PO q12h <sup>1,475</sup>                         | Ostrich chicks, pigeons (administration to adult birds led to therapeutic levels in crop milk)                                                                                                                                                                                                   |

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|  | 15 mg/kg PO, IM, IV<br>q12h <sup><a href="#">326</a></sup>                                                     | Raptors/PD; IV administration in owls may result in weakness, tachycardia, vasoconstriction                                   |
|  | 15 mg/kg PO, SC<br>q12h <sup><a href="#">244</a></sup>                                                         | Most species                                                                                                                  |
|  | 15-30 mg/kg PO, IM<br>q12h <sup><a href="#">248</a></sup>                                                      | African grey parrots/PD                                                                                                       |
|  | 20 mg/kg PO, SC, IM<br>q12h <sup><a href="#">323,702</a></sup>                                                 | Pigeons/administer parenterally, followed by oral treatment                                                                   |
|  | 20-30 mg/kg PO q12-24h <sup><a href="#">222</a></sup>                                                          | Pigeons                                                                                                                       |
|  | 25 mg/kg PO, SC<br>q24h <sup><a href="#">244</a></sup>                                                         | Experimental                                                                                                                  |
|  | 30 mg/kg PO, IM<br>q24h <sup><a href="#">812</a></sup>                                                         | Psittacines                                                                                                                   |
|  | 45 mg/kg PO q24h <sup><a href="#">323</a></sup>                                                                | Pigeons                                                                                                                       |
|  | 50 mg/kg via nebulization × 4 hr (day 1, AM), then 25 mg/kg × 4 hr/day × 4 days <sup><a href="#">815</a></sup> | Muscovy, Pekin ducklings/ <i>Riemerella (Pasteurella)</i>                                                                     |
|  | 25-50 mg/L drinking water <sup><a href="#">85</a></sup>                                                        | Cranes (sandhill)/did not provide sufficient plasma levels                                                                    |
|  | 26 mg/L drinking water <sup><a href="#">119</a></sup>                                                          | Galliformes                                                                                                                   |
|  | 50 mg/L drinking water <sup><a href="#">342,414</a></sup>                                                      | Chickens, turkeys/PD                                                                                                          |
|  | 50-100 mg/L drinking water <sup><a href="#">102</a></sup>                                                      | Gamebirds                                                                                                                     |
|  | 100-200 mg/L drinking water <sup><a href="#">197,693,702</a></sup>                                             | Psittacines, pigeons/PD; may need up to 300 mg/L to prevent recurrence of infection in pigeons <sup><a href="#">702</a></sup> |
|  | 190-750 mg/L drinking water <sup><a href="#">250</a></sup>                                                     | African grey parrots/PD                                                                                                       |
|  | 200 mg/L drinking water <sup><a href="#">247</a></sup>                                                         | Psittacines/PD; maintains plasma concentrations adequate only for highly susceptible bacteria                                 |
|  | 200 mg/L drinking water <sup><a href="#">198</a></sup>                                                         | Canaries                                                                                                                      |
|  | 500 mg/L drinking water <sup><a href="#">467</a></sup>                                                         | Psittacines                                                                                                                   |

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|              | 200 mg/kg soft feed <sup><a href="#">198</a></sup>                                              | Canaries                                                                                                                                                                                 |
|              | 250 mg/kg feed <sup><a href="#">197</a></sup>                                                   | Budgerigars/PD                                                                                                                                                                           |
|              | 250-1000 mg/kg feed q24h <sup><a href="#">199,811</a></sup>                                     | Psittacines, passerines                                                                                                                                                                  |
|              | 500 mg/kg feed <sup><a href="#">467</a></sup>                                                   | Psittacines, including Patagonian conures/PD; mix into steamed corn diet                                                                                                                 |
|              | 1000 mg/kg feed <sup><a href="#">467</a></sup>                                                  | Senegal parrots/PD; mix into steamed corn diet                                                                                                                                           |
|              | 0.2 mg/mL saline, flush q24h × 10 days <sup><a href="#">63</a></sup>                            | Raptors/nasal flush                                                                                                                                                                      |
| Erythromycin | —                                                                                               | Macrolide; gram-positive spectrum; some activity against <i>Mycoplasma</i> ; <sup><a href="#">702</a></sup> IM injection may cause severe muscle necrosis <sup><a href="#">332</a></sup> |
|              | 5-10 mg/kg PO q8h <sup><a href="#">810</a></sup>                                                | Ratites                                                                                                                                                                                  |
|              | 10-20 mg/kg IM q24h <sup><a href="#">199</a></sup>                                              | Passerines                                                                                                                                                                               |
|              | 10-20 mg/kg PO q12h <sup><a href="#">702</a></sup>                                              | Psittacines                                                                                                                                                                              |
|              | 50-100 mg/kg PO q8-12h <sup><a href="#">199</a></sup>                                           | Passerines                                                                                                                                                                               |
|              | 55-110 mg/kg PO q12h <sup><a href="#">321</a></sup>                                             | Poultry/ <i>Mycoplasma</i> , <i>Haemophilus</i>                                                                                                                                          |
|              | 60 mg/kg PO q12h <sup><a href="#">354</a></sup>                                                 | Most species                                                                                                                                                                             |
|              | 71 mg/kg PO q24h <sup><a href="#">181</a></sup>                                                 | Pigeons/PD; <i>Streptococcus bovis</i>                                                                                                                                                   |
|              | 100 mg/kg PO <sup><a href="#">825</a></sup>                                                     | Pigeons/PD; low plasma levels, but higher lung and trachea levels                                                                                                                        |
|              | 125 mg/kg PO q8h <sup><a href="#">320</a></sup>                                                 | Pigeons                                                                                                                                                                                  |
|              | 102 mg/L drinking water <sup><a href="#">186</a></sup>                                          | Chicks/PD                                                                                                                                                                                |
|              | 125 mg/L drinking water <sup><a href="#">198</a></sup>                                          | Canaries                                                                                                                                                                                 |
|              | 132 mg/L drinking water (10 days on, 5 days off, 10 days on) <sup><a href="#">134,198</a></sup> | Most species, including canaries                                                                                                                                                         |
|              | 250-500 mg/L drinking water × 3-5 days <sup><a href="#">147</a></sup>                           | Psittacines                                                                                                                                                                              |
|              | 525-800 mg/L drinking                                                                           |                                                                                                                                                                                          |

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|                                      | water <sup>320</sup>                           | Psittacines                                                                                                                                                                                                 |
|                                      | 1000 mg/L drinking water <sup>181,825</sup>    | Pigeons/PD; <i>Streptococcus bovis</i> ; plasma levels low; one study reported that lung and trachea levels were sub-therapeutic                                                                            |
|                                      | 1500 mg/L drinking water <sup>702</sup>        | Most species                                                                                                                                                                                                |
|                                      | 200 mg/kg soft feed <sup>198</sup>             | Canaries, psittacines                                                                                                                                                                                       |
| Ethambutol (Myambutol, Lederle)      | —                                              | Most species/ <i>Mycobacterium</i> ; use in combination with other agents (see <a href="#">Table 5-45</a> )                                                                                                 |
|                                      | 10 mg/kg PO q12h <sup>50</sup>                 | Most species                                                                                                                                                                                                |
|                                      | 15-20 mg/kg PO q12h × 3-12 mo <sup>63,64</sup> | Psittacines, raptors/ <i>Mycobacterium</i>                                                                                                                                                                  |
|                                      | 15-30 mg/kg PO q12-24h <sup>200</sup>          | Passerines/ <i>Mycobacterium</i>                                                                                                                                                                            |
|                                      | 30 mg/kg PO q24h <sup>695</sup>                | Most species/ <i>Mycobacterium</i>                                                                                                                                                                          |
| Flumequine (Biocik, Amacol)          | —                                              | Quinolone; not available in the United States; may cause emesis                                                                                                                                             |
|                                      | 30 mg/kg PO, IM q8-12h <sup>195,200</sup>      | Passerines, pigeons (PD)                                                                                                                                                                                    |
| Furazolidone (NF180, Hess and Clark) | —                                              | Nitrofurantoin derivative; prohibited in food-producing birds because of its carcinogenic properties; use in birds linked with cardiomyopathy; therapeutic action is confined to the gastrointestinal tract |
|                                      | 15-20 mg/kg PO q24h <sup>200</sup>             | Passerines                                                                                                                                                                                                  |
|                                      | 100-200 mg/L drinking water <sup>672</sup>     | Canaries                                                                                                                                                                                                    |
|                                      | 200 mg/kg soft food <sup>672</sup>             | Canaries                                                                                                                                                                                                    |
|                                      | 220-440 mg/kg feed <sup>119</sup>              | Waterfowl/ <i>Salmonella</i>                                                                                                                                                                                |
|                                      | 908 mg/kg feed <sup>808</sup>                  | Pigeons/ <i>Salmonella</i>                                                                                                                                                                                  |
| Gentamicin                           | —                                              | Aminoglycoside; not generally recommended; narrow margin of safety; nephrotoxic; <sup>17,66,67</sup> bird should be well hydrated; avoid doses higher than 2.5-5 mg/kg q8-12h <sup>67,253</sup>             |
|                                      | 1-2 mg/kg IM q8h <sup>810</sup>                | Ratites (excluding emus)/use only as last resort                                                                                                                                                            |

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|                                 | 2.5 mg/kg IM q8h <sup>67</sup>                              | Raptors/PD                                                                                                                                                       |
|                                 | 3-10 mg/kg IM q6-12h <sup>200</sup>                         | Passerines                                                                                                                                                       |
|                                 | 5 mg/kg IM q8h <sup>98,165,384</sup>                        | Pheasants, emus (PD), cranes (PD)                                                                                                                                |
|                                 | 5 mg/kg IM q12h <sup>253</sup>                              | Ostriches, emus/PD; rapidly eliminated; small volume of distribution                                                                                             |
|                                 | 5-10 mg/kg IM q8-12h <sup>643</sup>                         | Cockatiels/PD                                                                                                                                                    |
|                                 | 5-10 mg/kg IM q4h <sup>98,699</sup>                         | Pigeons/PD; <i>Salmonella</i>                                                                                                                                    |
|                                 | 10 mg/kg IM q6h <sup>98,165</sup>                           | Quail/PD                                                                                                                                                         |
|                                 | 40 mg/kg PO q8-24h <sup>200</sup>                           | Passerines/15-25 g BW                                                                                                                                            |
|                                 | 2-3 drops ophthalmic solution intranasal q8h <sup>811</sup> | Most species                                                                                                                                                     |
| Isoniazid                       | —                                                           | Most species/ <i>Mycobacterium</i> ; should be used in combination with other drugs (see <a href="#">Table 5-45</a> ); <i>M. avium</i> often develops resistance |
|                                 | 5-15 mg/kg PO q12h <sup>199,671,811</sup>                   | Most species, including passerines                                                                                                                               |
|                                 | 30 mg/kg PO q24h <sup>824</sup>                             | Most species                                                                                                                                                     |
| Kanamycin (Kantrim, Fort Dodge) | —                                                           | Aminoglycoside                                                                                                                                                   |
|                                 | 10-20 mg/kg IM q12h <sup>16,199</sup>                       | Most species, including passerines/enteric infections                                                                                                            |
|                                 | 13-65 mg/L drinking water × 3-5 days <sup>16,96</sup>       | Most species/make fresh daily                                                                                                                                    |
| Lincomycin                      | —                                                           | Gram-positive/anaerobic spectrum indicated for pododermatitis, chronic dermatitis, and mycoplasmosis <sup>702</sup>                                              |
|                                 | 0.25-0.5 mL intraarticular q24h × 7-10 days <sup>702</sup>  | Raptors                                                                                                                                                          |
|                                 | 25-50 mg/kg PO q12h <sup>316</sup>                          | Raptors/musculoskeletal surgical repair                                                                                                                          |
|                                 | 35-50 mg/kg PO q12-24h <sup>200</sup>                       | Passerines                                                                                                                                                       |
|                                 | 35-50 mg/pigeon q24h × 7-14 days <sup>510</sup>             | Pigeons                                                                                                                                                          |

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|                                                                                                            | 50-75 mg/kg PO, IM<br>q12h × 7-10<br>days <sup><a href="#">64,149,702</a></sup>       | Psittacines, raptors/pododermatitis,<br>osteomyelitis                                                                                                                                                                                                                                                                         |
|                                                                                                            | 100 mg/kg PO q24h <sup><a href="#">671</a></sup>                                      | Raptors                                                                                                                                                                                                                                                                                                                       |
|                                                                                                            | 100 mg/kg IM q12h <sup><a href="#">64</a></sup>                                       | Psittacines                                                                                                                                                                                                                                                                                                                   |
|                                                                                                            | 100-200 mg/L drinking<br>water <sup><a href="#">198</a></sup>                         | Canaries                                                                                                                                                                                                                                                                                                                      |
|                                                                                                            | 2000 mg/L drinking<br>water × 5-7 days <sup><a href="#">63</a></sup>                  | Waterfowl/ <i>Pasteurella</i> , mycoplasmal<br>tenosynovitis                                                                                                                                                                                                                                                                  |
|                                                                                                            | Topical <sup><a href="#">316</a></sup>                                                | Raptors/mixture of lincomycin (50<br>mg/mL) and tobramycin (10 mg/mL) was<br>used to flush the flexor tendon sheath                                                                                                                                                                                                           |
| Lincomycin/spectinomycin (LS-<br>50 Water Soluble, Upjohn;<br>Linco-Spectin 100 Soluble<br>Powder, Upjohn) | —                                                                                     | Effective against gram-positive bacteria,<br><i>Mycoplasma</i>                                                                                                                                                                                                                                                                |
|                                                                                                            | 50 mg/kg PO q24h <sup><a href="#">534</a></sup>                                       | Most species                                                                                                                                                                                                                                                                                                                  |
|                                                                                                            | 528 mg/L drinking<br>water for first 5 days of<br>life <sup><a href="#">309</a></sup> | Turkey poult/DP; <i>Mycoplasma</i><br>airsacculitis                                                                                                                                                                                                                                                                           |
|                                                                                                            | 750 mg/L drinking<br>water × 3-7 days <sup><a href="#">119</a></sup>                  | Waterfowl                                                                                                                                                                                                                                                                                                                     |
|                                                                                                            | ¼-½ tsp/L drinking<br>water × 10-14 days <sup><a href="#">134</a></sup>               | Most species/using soluble powder 16.7 g<br>lincomycin and 33.3 g spectinomycin per<br>2.55 oz powder                                                                                                                                                                                                                         |
|                                                                                                            | 2.5-5 mg/chick IM <sup><a href="#">310</a></sup><br>once                              | Chicken chicks/DP; may prevent <i>E. coli</i><br>and <i>Staphylococcus aureus</i> infections;<br>injectable form not available in the United<br>States                                                                                                                                                                        |
| Marbofloxacin (Zeniquin,<br>Pfizer)                                                                        | —                                                                                     | Fluoroquinolone; not approved for use in<br>food-producing birds; <sup><a href="#">258</a></sup> less likely to<br>cause emesis compared to<br>enrofloxacin; <sup><a href="#">702</a></sup> use with caution in<br>juvenile birds; <sup><a href="#">341</a></sup> may adversely affect<br>molt <sup><a href="#">149</a></sup> |
|                                                                                                            | 2 mg/kg PO q24h <sup><a href="#">26</a></sup>                                         | Broiler chickens/DP                                                                                                                                                                                                                                                                                                           |
|                                                                                                            | 2-3 mg/kg IV, IO<br>q24h <sup><a href="#">280,281</a></sup>                           | Raptors/DP                                                                                                                                                                                                                                                                                                                    |
|                                                                                                            | 2.5-5 mg/kg PO q24h <sup><a href="#">116</a></sup>                                    | Blue and gold macaws/DP                                                                                                                                                                                                                                                                                                       |
|                                                                                                            | 3-12 mg/kg PO q24h <sup><a href="#">319</a></sup>                                     | Turkeys/DP                                                                                                                                                                                                                                                                                                                    |
|                                                                                                            | 5 mg/kg PO q24h <sup><a href="#">146</a></sup>                                        | Most species                                                                                                                                                                                                                                                                                                                  |
|                                                                                                            | 5 mg/kg IM, IV <sup><a href="#">183</a></sup>                                         | Ostriches/DP                                                                                                                                                                                                                                                                                                                  |

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|                            | 10-15 mg/kg PO, IM<br>q12-24h <sup><a href="#">63,149,279,702</a></sup> | Raptors, bustards/PD                                                                                                                                                                                                                      |
| Meropenem (Merrem, Abbott) | —                                                                       | Broad-spectrum carbapenem antibiotic; penetrates well into most body fluids and tissues, including cerebrospinal fluid                                                                                                                    |
|                            | 175 mg/kg IM q24h <sup><a href="#">725</a></sup>                        | Pigeons/PD                                                                                                                                                                                                                                |
| Metronidazole              | —                                                                       | Active against most anaerobes; see <a href="#">Table 5-4</a>                                                                                                                                                                              |
|                            | 10 mg/kg IM q24h × 2 days <sup><a href="#">812</a></sup>                | Psittacines                                                                                                                                                                                                                               |
|                            | 10-30 mg/kg PO q12h × 10 days <sup><a href="#">812</a></sup>            | Psittacines                                                                                                                                                                                                                               |
|                            | 50 mg/kg PO q24h × 5-7 days <sup><a href="#">50,63,609</a></sup>        | Most species, including raptors, psittacines/anaerobes                                                                                                                                                                                    |
|                            | 50 mg/kg PO q12h × 30 days <sup><a href="#">692</a></sup>               | Amazon parrots, cockatoos/anaerobic and hemorrhagic enteritis                                                                                                                                                                             |
| Minocycline                | —                                                                       | Products or foods containing Ca, Al, Mg, Fe reduce or alter absorption; outdated tetracycline is nephrotoxic <sup><a href="#">270</a></sup>                                                                                               |
|                            | 10 mg/kg PO q12h <sup><a href="#">559</a></sup>                         | Penguins                                                                                                                                                                                                                                  |
|                            | 15 mg/kg PO q12h <sup><a href="#">649</a></sup>                         | Raptors/some anaerobes                                                                                                                                                                                                                    |
|                            | 5000 mg/kg feed <sup><a href="#">16</a></sup>                           | Parakeets/use as antibiotic impregnated millet                                                                                                                                                                                            |
| Miporamicin                | 100 mg/kg feed × 5 days <sup><a href="#">787</a></sup>                  | Poultry/macrolide; under development; make preparation fresh daily                                                                                                                                                                        |
| Neomycin                   | —                                                                       | Aminoglycoside/not absorbed from gastrointestinal tract; potentially nephrotoxic when administered IM; use is generally limited to topical formulations for skin, eyes, and ears, and, occasionally, oral treatment of enteric infections |
|                            | 5-10 mg/kg IM q12h <sup><a href="#">341</a></sup>                       | Raptors/toxic if overdosed                                                                                                                                                                                                                |
|                            | 10 mg/kg PO q24h <sup><a href="#">200</a></sup>                         | Passerines                                                                                                                                                                                                                                |
|                            | 10 mg/kg PO q8-12h <sup><a href="#">96</a></sup>                        | Most species                                                                                                                                                                                                                              |
|                            | 80-100 mg/L drinking water <sup><a href="#">672</a></sup>               | Canaries                                                                                                                                                                                                                                  |
|                            | 80-264 mg/L drinking water <sup><a href="#">119</a></sup>               | Waterfowl                                                                                                                                                                                                                                 |
|                            | 126 mg/L drinking water <sup><a href="#">102</a></sup>                  | Galliformes                                                                                                                                                                                                                               |



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|                                                                                | 70-220 mg/kg feed × 14-21 days <sup><a href="#">70,119</a></sup>   | Waterfowl, galliformes/ <i>Clostridium</i> , necrotizing enteritis                                                                                                                                                                                    |
|                                                                                | Topical q6-12h <sup><a href="#">672</a></sup>                      | Most species/superficial wounds; cover with bandage; may be absorbed systemically and may cause ototoxicity and nephrotoxicity                                                                                                                        |
| Nitrofurantoin                                                                 | —                                                                  | Systemic and topical use banned in poultry used for human consumption because of its carcinogenic properties <sup><a href="#">257</a></sup>                                                                                                           |
|                                                                                | 26 mg/L drinking water × 5-7 days <sup><a href="#">119</a></sup>   | Galliformes                                                                                                                                                                                                                                           |
|                                                                                | 50-200 mg/kg feed × 5-7 days <sup><a href="#">119</a></sup>        | Galliformes/ <i>Clostridium</i> , <i>Salmonella</i>                                                                                                                                                                                                   |
| Nitrofurazone                                                                  | —                                                                  | Systemic use banned in food-producing birds because of its carcinogenic properties; <sup><a href="#">257</a></sup> may be hepatotoxic; avoid use or reduce dosage in hot weather; do not use in finches or pigeons <sup><a href="#">468,693</a></sup> |
|                                                                                | 0.3 mg/L drinking water × 7 days <sup><a href="#">671</a></sup>    | Lories, mynahs/do not put in lory nectar                                                                                                                                                                                                              |
|                                                                                | 0.6 mg/L drinking water × 7-10 days <sup><a href="#">518</a></sup> | Most species                                                                                                                                                                                                                                          |
| Norfloxacin (Noroxin, Merck; Vetriflox 20% Oral Solution, Lavet Ltd, Budapest) | —                                                                  | Fluoroquinolone; not approved for use in food-producing birds; <sup><a href="#">258</a></sup> administration of the total daily dose to chickens over 2-4 hr (pulse dosing) has been recommended <sup><a href="#">765</a></sup>                       |
|                                                                                | 3-5 mg/kg PO q12h <sup><a href="#">810</a></sup>                   | Ratites                                                                                                                                                                                                                                               |
|                                                                                | 8 mg/kg PO q24h <sup><a href="#">27</a></sup>                      | Chickens/PD                                                                                                                                                                                                                                           |
|                                                                                | 10 mg/kg PO q24h <sup><a href="#">439</a></sup>                    | Chickens, geese/PD                                                                                                                                                                                                                                    |
|                                                                                | 10 mg/kg PO q6-8h <sup><a href="#">439</a></sup>                   | Turkeys/PD                                                                                                                                                                                                                                            |
|                                                                                | 15 mg/kg in water over 2-4 hr <sup><a href="#">716</a></sup>       | Turkeys/PD; once per day pulse dosing was more efficacious than continuous dosing in the water                                                                                                                                                        |
|                                                                                | 20-40 mg/kg PO q24h × 5 days <sup><a href="#">476</a></sup>        | Chickens                                                                                                                                                                                                                                              |
|                                                                                | 100 mg/L drinking water × 5 days <sup><a href="#">716</a></sup>    | Chickens/PD                                                                                                                                                                                                                                           |
|                                                                                | 175 mg/L drinking water × 5 days <sup><a href="#">681</a></sup>    | Chickens                                                                                                                                                                                                                                              |
|                                                                                | 15-30 mg/kg PO                                                     | Poultry/effective against some gram-                                                                                                                                                                                                                  |



|                                              |                                                                        |                                                                                                                                                                                                                                                                                                      |
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| Novobiocin sodium                            | q24h <sup><a href="#">787</a></sup>                                    | positive cocci                                                                                                                                                                                                                                                                                       |
|                                              | 220-385 mg/kg feed <sup><a href="#">511</a></sup>                      | Poultry, waterfowl                                                                                                                                                                                                                                                                                   |
| Oleandomycin                                 | —                                                                      | Macrolide; not available in the United States                                                                                                                                                                                                                                                        |
|                                              | 25 mg/kg IM q24h <sup><a href="#">200</a></sup>                        | Passerines                                                                                                                                                                                                                                                                                           |
|                                              | 50 mg/kg PO q24h <sup><a href="#">200</a></sup>                        | Passerines                                                                                                                                                                                                                                                                                           |
| Orbifloxacin (Orbax, Schering-Plough)        | 15-20 mg/kg PO q24h <sup><a href="#">335</a></sup>                     | Japanese quail/PD                                                                                                                                                                                                                                                                                    |
|                                              | —                                                                      | See sulfonamides                                                                                                                                                                                                                                                                                     |
| Ormetoprim-sulfadimethoxine (Primor, Pfizer) | 60 mg/kg PO q12h <sup><a href="#">323</a></sup>                        | Pigeons                                                                                                                                                                                                                                                                                              |
|                                              | 475-951 mg/L drinking water × 7-10 days <sup><a href="#">323</a></sup> | Pigeons                                                                                                                                                                                                                                                                                              |
|                                              | 200-800 mg/kg feed <sup><a href="#">119</a></sup>                      | Waterfowl/colibacillosis                                                                                                                                                                                                                                                                             |
| Oxytetracycline                              | —                                                                      | IM administration may cause muscle irritation or necrosis; may be useful in treating <i>Chlamydophila</i> , fowl cholera; <sup><a href="#">849</a></sup> products or foods containing Al, Ca, Mg, Fe reduce or alter absorption; outdated tetracycline is nephrotoxic <sup><a href="#">270</a></sup> |
|                                              | 2 mg/mL nebulization q4-6h <sup><a href="#">208</a></sup>              | Parakeets/requires ultrasonic nebulizer; therapeutic concentrations of antibiotic were present in lung and trachea; not effective in treating systemic infections outside the respiratory tract                                                                                                      |
|                                              | 5 mg/kg SC, IM q12-24h <sup><a href="#">72</a></sup>                   | Chicken chicks/PD                                                                                                                                                                                                                                                                                    |
|                                              | 5 mg/kg IM q12h <sup><a href="#">841</a></sup>                         | Ratites                                                                                                                                                                                                                                                                                              |
|                                              | 10 mg/kg IM q3d <sup><a href="#">810</a></sup>                         | Ratites                                                                                                                                                                                                                                                                                              |
|                                              | 15-50 mg/kg SC, IM q12-24h <sup><a href="#">200</a></sup>              | Passerines                                                                                                                                                                                                                                                                                           |
|                                              | 16 mg/kg IM q24h <sup><a href="#">795</a></sup>                        | Great horned owls/PD                                                                                                                                                                                                                                                                                 |
|                                              | 23 mg/kg IV q6-8h <sup><a href="#">795</a></sup>                       | Pheasants/PD                                                                                                                                                                                                                                                                                         |
|                                              | 25-50 mg/kg PO, IM q8h × 5-7 days <sup><a href="#">63</a></sup>        | Raptors                                                                                                                                                                                                                                                                                              |
|                                              | 43 mg/kg IM q24h <sup><a href="#">795</a></sup>                        | Pheasants/PD                                                                                                                                                                                                                                                                                         |
|                                              | 48 mg/kg IM q48h <sup><a href="#">363</a></sup>                        | Owls                                                                                                                                                                                                                                                                                                 |
|                                              | 50 mg/kg IM q24h × 5-7 days <sup><a href="#">702</a></sup>             | Psittacines                                                                                                                                                                                                                                                                                          |

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|                                | 50 mg/kg PO q6-8h <sup><a href="#">320</a></sup>                                | Pigeons                                                                                                                                                                                                                   |
|                                | 50-75 mg/kg SC <sup><a href="#">242</a></sup>                                   | Goffin's cockatoos, blue and gold macaws                                                                                                                                                                                  |
|                                | 50-100 mg/kg SC, IM q2-3d <sup><a href="#">200,251</a></sup>                    | Cockatoos (PD), passerines                                                                                                                                                                                                |
|                                | 50-200 mg/kg IM q3-5d <sup><a href="#">702</a></sup>                            | Raptors                                                                                                                                                                                                                   |
|                                | 58 mg/kg IM q24h <sup><a href="#">795</a></sup>                                 | Amazon parrots/PD                                                                                                                                                                                                         |
|                                | 80 mg/kg IM q48h <sup><a href="#">702</a></sup>                                 | Pigeons <400 g                                                                                                                                                                                                            |
|                                | 200 mg/kg IM q24h <sup><a href="#">50,63</a></sup>                              | Most species including waterfowl/ <i>Pasteurella</i>                                                                                                                                                                      |
|                                | 130-400 mg/L drinking water <sup><a href="#">70,320</a></sup>                   | Pigeons                                                                                                                                                                                                                   |
|                                | 650-2000 mg/L drinking water × 5-14 days <sup><a href="#">147</a></sup>         | Psittacines                                                                                                                                                                                                               |
|                                | 2500 mg/L drinking water and 2500 mg/kg feed <sup><a href="#">702,873</a></sup> | Chickens (PD), turkeys (PD), waterfowl/simultaneous medication of feed and water required to reach therapeutic level                                                                                                      |
|                                | 300 mg/kg soft feed × 5-14 days <sup><a href="#">147</a></sup>                  | Psittacines                                                                                                                                                                                                               |
| Penicillin                     | 50,000 IU/kg IM <sup><a href="#">119</a></sup>                                  | Waterfowl/ <i>Erysipelas</i> , new duck disease                                                                                                                                                                           |
|                                | 8 g/40 g packet bone cement <sup><a href="#">814</a></sup>                      | PMMA beads (ratio 1:5)                                                                                                                                                                                                    |
| Penicillin benzathine/procaine | —                                                                               | Anecdotal reports suggest procaine penicillin should not be used in birds <1 kg BW because of possible toxic effects <sup><a href="#">811</a></sup>                                                                       |
|                                | 200 mg/kg IM q24h <sup><a href="#">50</a></sup>                                 | Most species                                                                                                                                                                                                              |
| Penicillin G                   | 6 mg/kg IV <sup><a href="#">130</a></sup>                                       | Ostriches, emus/PD; rapidly eliminated; small volume of distribution                                                                                                                                                      |
| Penicillin procaine            | —                                                                               | Anecdotal reports suggest procaine penicillin should not be used in birds <1 kg BW; adverse reactions (possible toxic effects) described in finches, canaries, budgerigars, cockatiels <sup><a href="#">239,811</a></sup> |
|                                | 100 mg/kg IM q24-48h <sup><a href="#">349</a></sup>                             | Turkeys/PD                                                                                                                                                                                                                |
|                                |                                                                                 | Extended-spectrum penicillin with broad-spectrum activity against many gram-positive and gram-negative aerobic and anaerobic organisms including                                                                          |

|                                                 |                                                                           |                                                                                                                                                                 |
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| Piperacillin (Pipracil, Wyeth)                  | —                                                                         | <i>Pseudomonas</i> ; <sup>702</sup> not available as a veterinary product in the United States; see piperacillin/tazobactam below <sup>564</sup>                |
|                                                 | 25 mg/kg IM <sup>811</sup>                                                | Ratites (chicks <6 mo of age)                                                                                                                                   |
|                                                 | 75-100 mg/kg IM q4-6h <sup>811,812</sup>                                  | Amazon parrots                                                                                                                                                  |
|                                                 | 100 mg/kg IM q12h <sup>197</sup>                                          | Psittacines/PD                                                                                                                                                  |
|                                                 | 100 mg/kg IM q12h <sup>1</sup>                                            | Ostrich chicks/administer concurrent to amikacin (20 mg/kg IM q12h)                                                                                             |
|                                                 | 100 mg/kg IM, IV q8-12h <sup>577,649,702</sup>                            | Pigeons, raptors, cranes                                                                                                                                        |
|                                                 | 100 mg/kg IM q4-6h <sup>678</sup>                                         | Red-tailed hawks, great horned owls/PD                                                                                                                          |
|                                                 | 100-200 mg/kg IM, IV q6-12h <sup>696,702</sup>                            | Most species, including psittacines                                                                                                                             |
|                                                 | 200 mg/kg IM q8h <sup>666</sup>                                           | Budgerigars (PD), raptors                                                                                                                                       |
|                                                 | 200 mg/kg IM, IV q4-8h <sup>244,696,811</sup>                             | Most species, including passerines                                                                                                                              |
|                                                 | 0.02 mL (4 mg) in macaw eggs; 0.01 mL (2 mg) in small eggs <sup>517</sup> | Eggs/inject 200 mg/mL solution into air cell on days 14, 18, and 22                                                                                             |
| Piperacillin/tazobactam (Zosyn, Tazocin, Wyeth) | 100 mg/kg IM, IV q6-12h <sup>118,564</sup>                                | Most species, including psittacines/PD in Amazon parrots                                                                                                        |
| Polymyxin B                                     | —                                                                         | Polypeptide antibiotic; effective against most gram-negative bacteria; potentially significant adverse effects on the renal and neurologic systems <sup>5</sup> |
|                                                 | 10-15 mg/kg IM q24h <sup>341</sup>                                        | Raptors/not absorbed if given PO                                                                                                                                |
|                                                 | 50,000 U/L drinking water <sup>387</sup>                                  | Canaries                                                                                                                                                        |
|                                                 | 50,000 U/kg soft feed <sup>387</sup>                                      | Canaries                                                                                                                                                        |
| Povidone-iodine                                 | Topical to lesions, then wash off <sup>63</sup>                           | Raptors/wound cleansing; antibacterial, antifungal activity                                                                                                     |
| Rifabutin (Mycobutin, Pharmacia)                | 15-45 mg/kg PO q24h <sup>200,695,824</sup>                                | Most species including passerines/ <i>Mycobacterium</i> ; use in combination with other agents (see <a href="#">Table 5-45</a> )                                |
| Rifampicin                                      | —                                                                         | See rifampin                                                                                                                                                    |
|                                                 |                                                                           | Most species/ <i>Mycobacterium</i> ; use with                                                                                                                   |

|                                              |                                               |                                                                                                                                                                                        |
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| Rifampin                                     | —                                             | other agents (see <a href="#">Table 5-45</a> ); may cause/be associated with hepatitis, CNS signs, depression, and vomiting; yellow-orange urates observed in bustards <sup>702</sup>  |
|                                              | 10-20 mg/kg PO q12-24h <sup>200,702,811</sup> | Most species including passerines, psittacines/ <i>Mycobacterium</i>                                                                                                                   |
|                                              | 45 mg/kg PO q24h <sup>749,824</sup>           | Most species, including Amazon parrots, cranes                                                                                                                                         |
| Silver sulfadiazine                          | Topical q12-24h <sup>228,672</sup>            | Most species/burns, ulcers; Amazon foot necrosis; bandage application preferred                                                                                                        |
| Spectinomycin (Spectam, Agri Labs)           | 10-30 mg/kg IM q8-12h <sup>64</sup>           | Psittacines                                                                                                                                                                            |
|                                              | 25-35 mg/kg IM q8-12h <sup>322</sup>          | Pigeons                                                                                                                                                                                |
|                                              | 165-275 mg/L drinking water <sup>323</sup>    | Pigeons                                                                                                                                                                                |
|                                              | 200-400 mg/L drinking water <sup>198</sup>    | Canaries                                                                                                                                                                               |
|                                              | 400 mg/kg soft feed <sup>198</sup>            | Canaries                                                                                                                                                                               |
| Spiramycin (Provamycin, Rovamycin)           | —                                             | Macrolide; not available in the United States                                                                                                                                          |
|                                              | 20 mg/kg IM q24h <sup>341</sup>               | Raptors                                                                                                                                                                                |
|                                              | 250 mg/kg PO q24h <sup>511</sup>              | Most species, including raptors/poorly absorbed                                                                                                                                        |
|                                              | 200-400 mg/L drinking water <sup>198</sup>    | Canaries                                                                                                                                                                               |
|                                              | 400 mg/kg soft feed <sup>198</sup>            | Canaries                                                                                                                                                                               |
| Streptomycin (Streptomycin Sulfate, Roerig)  | —                                             | May be nephrotoxic; not recommended; <sup>672</sup> consider amikacin as an alternative; <i>Mycobacterium</i> ; use in combination with other agents (see <a href="#">Table 5-45</a> ) |
|                                              | 15 mg/kg PO q24h <sup>341</sup>               | Raptors/highly neurotoxic                                                                                                                                                              |
|                                              | 20-40 mg/kg PO q24h <sup>452</sup>            | Most species                                                                                                                                                                           |
|                                              | 25-50 mg/kg IM q24h                           | Chickens/PD                                                                                                                                                                            |
|                                              | 30 mg/kg IM q12h <sup>50</sup>                | Most species                                                                                                                                                                           |
| Sulfachlorpyridazine (Vetisulid, Fort Dodge) | —                                             | Antiprotozoal drug                                                                                                                                                                     |
|                                              | 150-300 mg/L drinking water <sup>672</sup>    | Canaries                                                                                                                                                                               |

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|                                                                            | 400 mg/L drinking water × 7-10 days <sup><a href="#">691</a></sup>                                    | Pigeons                                                                                                                                                                                                                                                                                                                                                                                      |
| Sulfadimethoxine (Albon, Pfizer)                                           | —                                                                                                     | Coccidiostat; see sulfonamides                                                                                                                                                                                                                                                                                                                                                               |
|                                                                            | 25-55 mg/kg PO q24h × 3-7 days <sup><a href="#">392,665</a></sup>                                     | Raptors/loading dose at higher end × 1 day                                                                                                                                                                                                                                                                                                                                                   |
|                                                                            | 50 mg/kg PO q24h <sup><a href="#">112</a></sup>                                                       | Cranes                                                                                                                                                                                                                                                                                                                                                                                       |
|                                                                            | 190-250 mg/L drinking water <sup><a href="#">511</a></sup>                                            | Pigeons/loading dose 375 mg/L drinking water                                                                                                                                                                                                                                                                                                                                                 |
|                                                                            | 330-400 mg/L drinking water on day 1 followed by 200-265 mg/L × 4 days <sup><a href="#">323</a></sup> | Pigeons                                                                                                                                                                                                                                                                                                                                                                                      |
| Sulfaquinoxaline (Sulquin 6-501, Solvay Animal Health; Sul-Q-Nox, Alfarma) | —                                                                                                     | See sulfonamides                                                                                                                                                                                                                                                                                                                                                                             |
|                                                                            | 250-500 mg/kg feed <sup><a href="#">119</a></sup>                                                     | Waterfowl/avian cholera, new duck disease                                                                                                                                                                                                                                                                                                                                                    |
| Sulfonamides                                                               | —                                                                                                     | Broad-spectrum antimicrobial; prohibited in food-producing birds; <sup><a href="#">849</a></sup> contraindicated with dehydration, liver disease, or bone marrow suppression; gastrointestinal upset, regurgitation are common especially in macaws; resistance by <i>Pseudomonas</i> is common; <sup><a href="#">696</a></sup> use for longer than 2 wk may require vitamin supplementation |
| Tetracycline                                                               | —                                                                                                     | Products or foods containing Al, Ca, Mg, Fe reduce or alter absorption; outdated tetracycline is nephrotoxic <sup><a href="#">270</a></sup>                                                                                                                                                                                                                                                  |
|                                                                            | 50 mg/kg PO q8h <sup><a href="#">200,672</a></sup>                                                    | Most species, including passerines                                                                                                                                                                                                                                                                                                                                                           |
|                                                                            | 200-250 mg/kg PO q12-24h <sup><a href="#">134,671</a></sup>                                           | Most species/gavage                                                                                                                                                                                                                                                                                                                                                                          |
|                                                                            | 40-200 mg/L drinking water <sup><a href="#">66,119,134</a></sup>                                      | Most species, including game birds                                                                                                                                                                                                                                                                                                                                                           |
|                                                                            | 100 mg/L drinking water <sup><a href="#">645</a></sup>                                                | Rheas                                                                                                                                                                                                                                                                                                                                                                                        |
|                                                                            | 200 mg/L drinking water <sup><a href="#">692</a></sup>                                                | Pigeons                                                                                                                                                                                                                                                                                                                                                                                      |
|                                                                            | 666 mg/L drinking water <sup><a href="#">702</a></sup>                                                | Pigeons                                                                                                                                                                                                                                                                                                                                                                                      |
|                                                                            | 100-600 mg/kg feed <sup><a href="#">70,119</a></sup>                                                  | Game birds                                                                                                                                                                                                                                                                                                                                                                                   |

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| Tiamulin (Denagard; Novartis)                                                      | —                                                        | Bacteriostatic antibiotic; effective against <i>Mycoplasma</i> , some gram-positive and gram-negative bacteria, and spirochetes <sup>614</sup>                            |
|                                                                                    | 12.5 mg/kg PO × 3 days <sup>94</sup>                     | Poultry/intestinal spirochetosis                                                                                                                                          |
|                                                                                    | 25-50 mg/kg PO q24h <sup>177</sup>                       | Most species                                                                                                                                                              |
|                                                                                    | 30 mg/kg PO q24h × 7 days <sup>629</sup>                 | Poultry adults                                                                                                                                                            |
|                                                                                    | 60 mg/kg PO q24h × 7 days <sup>629</sup>                 | Poultry chicks                                                                                                                                                            |
|                                                                                    | 225-250 mg/L drinking water × 3-7 days <sup>70,702</sup> | Poultry, pigeons                                                                                                                                                          |
|                                                                                    | 1000 mg/L water <sup>629</sup>                           | Poultry eggs/dip                                                                                                                                                          |
|                                                                                    | 300-400 mg/kg feed × 7 days <sup>70,629</sup>            | Game birds                                                                                                                                                                |
| Tiamulin/chlortetracycline (Tetramutin, Novartis)                                  | 1-1.5 mg/kg feed × 7 days <sup>772</sup>                 | Chickens/ <i>Mycoplasma</i> ; <i>Brachyspira</i> -related diseases; may be used with salinomycin at low doses of 60 mg/kg without signs of incompatibility <sup>371</sup> |
| Ticarcillin (Ticar, SmithKline Beecham)                                            | —                                                        | Extended-spectrum penicillin; very poor absorption if injectable given PO                                                                                                 |
|                                                                                    | 75-100 mg/kg IM q4-6h <sup>696</sup>                     | Amazon parrots                                                                                                                                                            |
|                                                                                    | 150-200 mg/kg IV q2-4h <sup>200</sup>                    | Passerines, soft bills                                                                                                                                                    |
|                                                                                    | 200 mg/kg IM, IV q6-12h <sup>96,693</sup>                | Most species, including pigeons, raptors/ <i>Pseudomonas</i> <sup>242</sup>                                                                                               |
|                                                                                    | 200 mg/kg IM q2-4h <sup>724</sup>                        | Blue-fronted Amazon parrots/PD                                                                                                                                            |
| Ticarcillin/clavulanate (Timentin, SmithKline Beecham)                             | 100 mg/kg IM, IV <sup>146</sup>                          | Most species/frequency not reported                                                                                                                                       |
|                                                                                    | 200 mg/kg IM, IV q12h <sup>692</sup>                     | Most species                                                                                                                                                              |
| Tilmicosin (Micotil 300 Injection, Provital-powder and Pulmotil AC-liquid, Elanco) | —                                                        | Macrolide; handle with caution; potentially fatal to humans <sup>614</sup>                                                                                                |
|                                                                                    | 30 mg/kg PO q24h <sup>9</sup>                            | Poultry/PD                                                                                                                                                                |
|                                                                                    | 100-500 mg/L drinking water × 5 days <sup>395,416</sup>  | Poultry chicks/ <i>Mycoplasma</i>                                                                                                                                         |
|                                                                                    |                                                          | Aminoglycoside; used only for severe infections caused by resistant                                                                                                       |

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| Tobramycin                                                               | —                                                               | <i>Pseudomonas</i> infections; <sup>702</sup> neurotoxicity (irreversible auditory and vestibular ototoxicity) or nephrotoxicity may develop <sup>5</sup> |
|                                                                          | 0.25-0.5 mL intraarticular flush q24h × 7-10 days <sup>63</sup> | Raptors/septic arthritis                                                                                                                                  |
|                                                                          | 2.5 mg/kg IM q8h <sup>147</sup>                                 | Psittacines                                                                                                                                               |
|                                                                          | 2.5-5 mg/kg IM, IV q12h <sup>696,702</sup>                      | Psittacines, passerines, raptors, pheasants, cranes                                                                                                       |
|                                                                          | 5 mg/kg IM q12h <sup>50</sup>                                   | Most species                                                                                                                                              |
|                                                                          | 10 mg/kg IM q12h × 5-7 days <sup>149,534</sup>                  | Raptors                                                                                                                                                   |
|                                                                          | Topical <sup>316</sup>                                          | A mixture of lincomycin (50 mg/mL) and tobramycin (10 mg/mL) was used to flush the flexor tendon sheath                                                   |
| Trimethoprim                                                             | —                                                               | Bacteriostatic activity against some gram-positive and gram-negative bacteria                                                                             |
|                                                                          | 10-20 mg/kg PO q8h <sup>195,199,511</sup>                       | Psittacines, passerines, pigeons (PD)                                                                                                                     |
| Trimethoprim/sulfadiazine (Tribrissen, Schering-Plough; Septra, Monarch) | —                                                               | See sulfonamides                                                                                                                                          |
|                                                                          | 8 mg/kg SC, IM q12h <sup>577</sup>                              | Cranes                                                                                                                                                    |
|                                                                          | 12-60 mg/kg PO q12h × 5-7 days <sup>63</sup>                    | Raptors/useful for sensitive infections in neonates                                                                                                       |
|                                                                          | 16-24 mg/kg PO q8-12h <sup>577</sup>                            | Cranes                                                                                                                                                    |
|                                                                          | 20 mg/kg SC, IM q12h <sup>147</sup>                             | Psittacines                                                                                                                                               |
|                                                                          | 30 mg/kg PO q8h <sup>343</sup>                                  | Psittacines; combine with pyrimethamine for treatment of sarcocystosis                                                                                    |
|                                                                          | 30 mg/kg PO, IM, IV q12h <sup>315</sup>                         | Ostriches/PD                                                                                                                                              |
|                                                                          | 60 mg/kg PO q12h <sup>323</sup>                                 | Pigeons                                                                                                                                                   |
|                                                                          | 107 mg/L drinking water <sup>70</sup>                           | Galliformes                                                                                                                                               |
|                                                                          | 475-950 mg/L drinking water × 7-10 days <sup>323</sup>          | Pigeons                                                                                                                                                   |
| Trimethoprim/sulfatroxazole                                              | —                                                               | See sulfonamides                                                                                                                                          |
|                                                                          | 10-50 mg/kg PO q12h <sup>200</sup>                              | Passerines                                                                                                                                                |



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| Trimethoprim/sulfamethoxazole<br>(Bactrim, Roche; Septra,<br>Burroughs Wellcome) | —                                                                          | See sulfonamides                                                                                                                                                                                                                                            |
|                                                                                  | 8 mg/kg IM q12h <sup><a href="#">702</a></sup>                             | Psittacines                                                                                                                                                                                                                                                 |
|                                                                                  | 10-50 mg/kg PO<br>q24h <sup><a href="#">200</a></sup>                      | Passerines                                                                                                                                                                                                                                                  |
|                                                                                  | 20 mg/kg PO q8-12h <sup><a href="#">702</a></sup>                          | Psittacines                                                                                                                                                                                                                                                 |
|                                                                                  | 21 mg/kg PO q12h <sup><a href="#">1</a></sup>                              | Ostriches                                                                                                                                                                                                                                                   |
|                                                                                  | 40-50 mg/kg PO<br>q12h <sup><a href="#">244</a></sup>                      | Psittacines                                                                                                                                                                                                                                                 |
|                                                                                  | 48 mg/kg PO, IM<br>q12h <sup><a href="#">397</a></sup>                     | Raptors                                                                                                                                                                                                                                                     |
|                                                                                  | 60 mg/kg PO q24h <sup><a href="#">195</a></sup>                            | Pigeons/PD                                                                                                                                                                                                                                                  |
|                                                                                  | 60-72 mg/kg PO<br>q12h <sup><a href="#">111</a></sup>                      | Cranes                                                                                                                                                                                                                                                      |
|                                                                                  | 75 mg/kg IM q12h <sup><a href="#">50</a></sup>                             | Most species/reduce dose if regurgitation<br>occurs <sup><a href="#">242</a></sup>                                                                                                                                                                          |
|                                                                                  | 100 mg/kg PO q12h <sup><a href="#">50</a></sup>                            | Most species, including psittacines                                                                                                                                                                                                                         |
|                                                                                  | 144 mg/kg PO q8-<br>12h <sup><a href="#">696</a></sup>                     | Most species                                                                                                                                                                                                                                                |
|                                                                                  | 360-400 mg/L drinking<br>water × 10-14 days <sup><a href="#">691</a></sup> | Most species, including pigeons                                                                                                                                                                                                                             |
|                                                                                  | 400 mg/kg feed <sup><a href="#">633</a></sup>                              | Geese                                                                                                                                                                                                                                                       |
| Tylosin (Tylan, Elanco)                                                          | —                                                                          | Macrolide; effective against gram-<br>positive bacteria, <i>Mycoplasma</i> ,<br><i>Chlamydophila</i> , <i>Pasteurella</i> ; very<br>irritating to muscles when administered<br>IM; poor absorption if injectable given<br>PO <sup><a href="#">322</a></sup> |
|                                                                                  | 3-5 mg/kg IM, IV<br>q12h <sup><a href="#">810</a></sup>                    | Ratites                                                                                                                                                                                                                                                     |
|                                                                                  | 5-10 mg/kg PO q8h <sup><a href="#">810</a></sup>                           | Ratites                                                                                                                                                                                                                                                     |
|                                                                                  | 6.6-11 mg/kg SC <sup><a href="#">c</a></sup>                               | Galliformes                                                                                                                                                                                                                                                 |
|                                                                                  | 10-40 mg/kg IM q6-<br>8h <sup><a href="#">200,672</a></sup>                | Poultry, passerines                                                                                                                                                                                                                                         |
|                                                                                  | 15 mg/kg IM q8h <sup><a href="#">469</a></sup>                             | Cranes/PD                                                                                                                                                                                                                                                   |
|                                                                                  | 15-30 mg/kg IM q12h ×<br>3 day <sup><a href="#">63,149</a></sup>           | Raptors                                                                                                                                                                                                                                                     |
|                                                                                  | 17 mg/kg IM q24h × 7<br>days <sup><a href="#">532</a></sup>                | Emus/ <i>Mycoplasma</i>                                                                                                                                                                                                                                     |



|                                |                                                                                                        |                                                                                      |
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|                                | 20-30 mg/kg IM q8h × 3-7 days <sup><a href="#">63</a></sup>                                            | Waterfowl/ <i>Mycoplasma</i>                                                         |
|                                | 20-40 mg/kg IM q8h <sup><a href="#">702</a></sup>                                                      | Psittacines                                                                          |
|                                | 25 mg/kg IM q8h <sup><a href="#">469</a></sup>                                                         | Emus/PD                                                                              |
|                                | 25 mg/kg IM q6h <sup><a href="#">469</a></sup>                                                         | Pigeons, quail/PD                                                                    |
|                                | 30 mg/kg IM q12h <sup><a href="#">63</a></sup>                                                         | Most species/ <i>Mycoplasma</i>                                                      |
|                                | 50 mg/kg PO q24h <sup><a href="#">70,200</a></sup>                                                     | Passerines, pigeons                                                                  |
|                                | 50 mg/L drinking water <sup><a href="#">692</a></sup>                                                  | Most species                                                                         |
|                                | 250-400 mg/L drinking water <sup><a href="#">198</a></sup>                                             | Canaries                                                                             |
|                                | 300 mg/L drinking water × 6 wk <sup><a href="#">568</a></sup>                                          | House finches/ <i>Mycoplasma</i>                                                     |
|                                | 500 mg/L drinking water × 3-28 days <sup><a href="#">70,395,702,788</a></sup>                          | Pigeons, galliformes, waterfowl, emus/ <i>Mycoplasma</i>                             |
|                                | 800 mg/L drinking water <sup><a href="#">323</a></sup>                                                 | Pigeons                                                                              |
|                                | 1000 mg/L drinking water × 21 days <sup><a href="#">512</a></sup>                                      | House finches/ <i>Mycoplasma</i> ; give in conjunction with ophthalmic ciprofloxacin |
|                                | 2000 mg/L drinking water <sup><a href="#">321,322</a></sup>                                            | Pigeons, poultry/ <i>Mycoplasma</i> , <i>Haemophilus</i>                             |
|                                | 200 mg/kg feed <sup><a href="#">70</a></sup>                                                           | Galliformes                                                                          |
|                                | 100 mg/10 mL saline nasal flush <sup><a href="#">44</a></sup> × 10 days <sup><a href="#">702</a></sup> | Waterfowl/ <i>Mycoplasma</i>                                                         |
| Virginiamycin (Stafac, Pfizer) | 22 mg/kg feed <sup><a href="#">787</a></sup>                                                           | Poultry                                                                              |

<sup>a</sup> Most drug doses used in birds should be considered experimental. Patients should be monitored for adverse effects and treatment failure.<sup>[242](#)</sup>

<sup>b</sup> Wojick K. Personal communication. 2011.

<sup>c</sup> Ley D. Personal communication. 1997.

TABLE 5-2 Antifungal Agents Used in Birds.

| Agent                 | Dosage                                                                                 | Species/Comments                                                                                                                                                                                                                                                                                                                                                            |
|-----------------------|----------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Acetic acid (vinegar) | 16 mL/L drinking water <sup>387</sup>                                                  | Most species/gastrointestinal yeast infections                                                                                                                                                                                                                                                                                                                              |
| Amphotericin B        | —                                                                                      | Fungicidal; lipid-based amphotericin B products are now available that have less toxicity than conventional desoxycholate form; <i>Macrorhabdus ornithogaster</i> (avian gastric yeast); preferred IV agent for aspergillosis; intratracheal administration for syringeal aspergilloma may cause tracheitis; potentially nephrotoxic; resistance may develop <sup>608</sup> |
|                       | 1.5 mg/kg IV q8h × 3-7 days <sup>52,238,651</sup>                                      | Most species                                                                                                                                                                                                                                                                                                                                                                |
|                       | 1 mg/kg intratracheal q8-12h, dilute to 1 mL with sterile water <sup>651,671,672</sup> | Psittacines, raptors/aspergillosis                                                                                                                                                                                                                                                                                                                                          |
|                       | 1 mg/kg intratracheal q12h × 12 days, then q48h × 5 wk <sup>63</sup>                   | Raptors/syringeal aspergilloma                                                                                                                                                                                                                                                                                                                                              |
|                       | 100-109 mg/kg PO by gavage q12h × 10-30 days <sup>511,535,609,614</sup>                | Budgerigars/avian gastric yeast (“megabacteria”); compound in simple syrup; resistance reported in budgerigars in Australia <sup>609</sup>                                                                                                                                                                                                                                  |
|                       | 0.05 mg/mL sterile water <sup>52</sup>                                                 | Most species/nasal flush                                                                                                                                                                                                                                                                                                                                                    |
|                       | 0.2 mL PO q12h × 10 days <sup>147</sup>                                                | Budgerigars/avian gastric yeast; use IV formulation (5 mg/mL)                                                                                                                                                                                                                                                                                                               |
|                       | 0.25-1 mL PO q24h × 4-5 days <sup>63</sup>                                             | Raptor neonates/candidiasis; not absorbed from alimentary tract                                                                                                                                                                                                                                                                                                             |
|                       | 1000 mg/L drinking water × 10 days <sup>231</sup>                                      | Budgerigars/avian gastric yeast                                                                                                                                                                                                                                                                                                                                             |
|                       | Topical <sup>147</sup>                                                                 | Apply 10% solution to oropharynx                                                                                                                                                                                                                                                                                                                                            |
|                       | 1.35 mg/kg topical q24h of a liposomally                                               |                                                                                                                                                                                                                                                                                                                                                                             |

|                                                   |                                                                                     |                                                                                                                                                                                                                                        |
|---------------------------------------------------|-------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                                                   | encapsulated formulation in a sterile, water-soluble lubricating gel <sup>74</sup>  | Heron                                                                                                                                                                                                                                  |
|                                                   | 7 mg/mL saline q12h <sup>814</sup>                                                  | Most species/nebulization × 15 min                                                                                                                                                                                                     |
| Amphotericin B (3% cream)                         | Topical to affected area q12h <sup>387,672</sup>                                    | Most species/mycoses                                                                                                                                                                                                                   |
| Amphotericin B (A)/proteolytic nasal flush (P)    | Nasal flush (A) 1 mg/kg + (P) 0.2-0.4 mL diluted in 20 mL saline <sup>11</sup> q24h | Uses a commercial neomycin-chymotrypsin-trypsin-hydrocortisone ointment (Kymar, Schering-Plough); 10 mL per naris (flushed vigorously in small amounts)                                                                                |
| Caprylic acid (Kaprycidin A, Ecological Formulas) | —                                                                                   | Naturally occurring fatty acid with antifungal properties                                                                                                                                                                              |
|                                                   | 271 mg/kg PO <sup>813</sup>                                                         | Most species/adjunctive treatment with imidazoles; seldom used                                                                                                                                                                         |
| Clotrimazole                                      | —                                                                                   | Broad-spectrum antifungal agent; inhibits the growth of pathogenic yeasts such as <i>Candida albicans</i> ; used commonly as adjunctive therapy for aspergillosis; administer via air sac, intratracheally, nebulization, or topically |
|                                                   | 2 mg/kg intratracheal q24h × 5 days <sup>692</sup>                                  | Psittacines/syringeal aspergilloma; apply with catheter directly into syrx during anesthesia                                                                                                                                           |
|                                                   | Inject 10 mg/kg into air sacs <sup>692</sup>                                        | Psittacines/dilute in propylene glycol to 2.5 mg/mL; divide total dose between the 4 most accessible air sacs; toxic and may result in death in African grey parrots and other birds if injected into the viscera or IM <sup>629</sup> |
|                                                   | 10 mg/mL saline flush <sup>238,609</sup>                                            | Most species/effective against <i>Aspergillus</i> at sites that can be flushed; nasal flush using 1% solution                                                                                                                          |
|                                                   | 1% solution <sup>814</sup>                                                          | Nebulization × 30-60 min                                                                                                                                                                                                               |
| Enilconazole emulsion                             | —                                                                                   | Imidazole antifungal agent with activity against <i>Penicillium</i> and dermatophytes <sup>16</sup>                                                                                                                                    |
|                                                   | 6 mg/kg PO q12h <sup>16</sup>                                                       | Eclectus parrots/glossal candidiasis; an elevation of AST was seen after 7 days of treatment                                                                                                                                           |
|                                                   | 1 mg (0.5 mL)/kg intratracheal of a 1:10 dilution q24h × 7-14 days <sup>702</sup>   | Falcons/aspergillosis                                                                                                                                                                                                                  |

|                                      |                                                                                                             |                                                                                                                                                                                                                                                                                                                                                                                                                                                               |
|--------------------------------------|-------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                                      | 200 mg/L<br>drinking water <sup>16</sup>                                                                    | Canaries/cutaneous dermatophytosis                                                                                                                                                                                                                                                                                                                                                                                                                            |
|                                      | Topical 1:10<br>dilution q12h ×<br>21-28 days <sup>63</sup>                                                 | Raptors/cutaneous aspergillosis, candidiasis                                                                                                                                                                                                                                                                                                                                                                                                                  |
|                                      | Topical or<br>intratracheal<br>1:10-1:100<br>dilution <sup>64</sup>                                         | Psittacines/aspergillosis, candidiasis                                                                                                                                                                                                                                                                                                                                                                                                                        |
|                                      | 3 topical<br>soakings q3d <sup>651</sup>                                                                    | Raptors, ostriches/dermatophytosis                                                                                                                                                                                                                                                                                                                                                                                                                            |
|                                      | 0.1 mL/kg in 5<br>mL sterile water,<br>nebulize × 30<br>min, 5 days on, 2<br>off, up to 3 mo <sup>338</sup> | Raptors/aspergillosis                                                                                                                                                                                                                                                                                                                                                                                                                                         |
| Fluconazole<br>(Diflucan,<br>Pfizer) | —                                                                                                           | Fungistatic; penetrates well into brain, cerebrospinal fluid, and eyes; <sup>16</sup> only indicated if topical treatment (i.e., nystatin) is not feasible; <sup>16</sup> water-soluble; safest therapeutic index of the azoles; <i>Candida</i> , avian gastric yeast; may be ineffective against aspergillosis; <sup>651</sup> death observed in budgerigars at 10 mg/kg PO q12h (this dose was also ineffective against avian gastric yeast) <sup>609</sup> |
|                                      | 2-5 mg/kg PO<br>q24h × 7-10<br>days <sup>63,583</sup>                                                       | Most species, including raptors/gastrointestinal, systemic candidiasis; CNS, ocular mycoses                                                                                                                                                                                                                                                                                                                                                                   |
|                                      | 4-6 mg/kg PO<br>q12h <sup>240</sup>                                                                         | Juvenile psittacines/candidiasis                                                                                                                                                                                                                                                                                                                                                                                                                              |
|                                      | 5 mg/kg PO<br>q24h <sup>648</sup>                                                                           | Cockatiels/candidiasis                                                                                                                                                                                                                                                                                                                                                                                                                                        |
|                                      | 5-10 mg/kg PO<br>q24h <sup>49</sup>                                                                         | Gouldian finches/candidiasis                                                                                                                                                                                                                                                                                                                                                                                                                                  |
|                                      | 5-15 mg/kg PO<br>q12h × 14-60<br>days or longer <sup>692</sup>                                              | Most species/aspergillosis, mycelial candidiasis; use lower dose for candidiasis                                                                                                                                                                                                                                                                                                                                                                              |
|                                      | 8 mg/kg PO q24h<br>× 30 days <sup>812</sup>                                                                 | Psittacines/cryptococcosis                                                                                                                                                                                                                                                                                                                                                                                                                                    |
|                                      | 10 mg/kg PO<br>q48h <sup>648</sup>                                                                          | Cockatiels/candidiasis                                                                                                                                                                                                                                                                                                                                                                                                                                        |
|                                      | 10-20 mg/kg PO<br>× 30 days <sup>387</sup>                                                                  | Red-tailed hawks, gyrfalcons/aspergillosis                                                                                                                                                                                                                                                                                                                                                                                                                    |
|                                      | 15 mg/kg PO                                                                                                 |                                                                                                                                                                                                                                                                                                                                                                                                                                                               |

|                              |                                                                                                |                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
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|                              | q12h × ≥ 28 days <sup><a href="#">694</a></sup>                                                | Pigeons/aspergillosis                                                                                                                                                                                                                                                                                                                                                                                                                                              |
|                              | 15 mg/kg PO q12h × 30 days following cessation of clinical signs <sup><a href="#">11</a></sup> | Psittacines/chronic nasal aspergillosis                                                                                                                                                                                                                                                                                                                                                                                                                            |
|                              | 20 mg/kg PO q48h <sup><a href="#">240</a></sup>                                                | Psittacines/PD; mucosal, systemic yeast infections; 2-3 treatments for resistant candidiasis                                                                                                                                                                                                                                                                                                                                                                       |
|                              | 100 mg/kg PO q24h <sup><a href="#">608</a></sup>                                               | Chickens/avian gastric yeast                                                                                                                                                                                                                                                                                                                                                                                                                                       |
|                              | 100 mg/kg soft food <sup><a href="#">49</a></sup>                                              | Gouldian finches/candidiasis                                                                                                                                                                                                                                                                                                                                                                                                                                       |
|                              | 25 mg/L nectar <sup><a href="#">331</a></sup>                                                  | Hummingbirds/aspergillosis                                                                                                                                                                                                                                                                                                                                                                                                                                         |
|                              | 50 mg/L drinking water × 14-60 days <sup><a href="#">692</a></sup>                             | Most species/systemic mycoses; candidiasis                                                                                                                                                                                                                                                                                                                                                                                                                         |
|                              | 100 mg/L drinking water × 8 days <sup><a href="#">648</a></sup>                                | Cockatiels/candidiasis                                                                                                                                                                                                                                                                                                                                                                                                                                             |
|                              | 150 mg/L drinking water <sup><a href="#">49</a></sup>                                          | Gouldian finches/candidiasis                                                                                                                                                                                                                                                                                                                                                                                                                                       |
| Flucytosine (Ancobon, Roche) | —                                                                                              | Fungistatic agent; penetrates well into CNS; used prophylactically in raptors (especially falcons) and waterfowl to prevent aspergillosis; <sup><a href="#">a</a></sup> may be administered as adjunctive treatment; about 50% of <i>Aspergillus</i> strains are resistant; <sup><a href="#">680</a></sup> toxicity is low, however adverse effects may include gastrointestinal effects, hepatotoxicity, bone marrow depression <sup><a href="#">80,680</a></sup> |
|                              | 20-30 mg/kg PO q6h × 20-90 days <sup><a href="#">363</a></sup>                                 | Raptors/aspergillosis                                                                                                                                                                                                                                                                                                                                                                                                                                              |
|                              | 20-75 mg/kg PO q12h × 21 days <sup><a href="#">702</a></sup>                                   | Psittacines/generalized yeast or fungal infections                                                                                                                                                                                                                                                                                                                                                                                                                 |
|                              | 50 mg/kg PO q12h × 14-28 days <sup><a href="#">147,583</a></sup>                               | Psittacines, passerines, raptors                                                                                                                                                                                                                                                                                                                                                                                                                                   |
|                              | 50-75 mg/kg PO q8h <sup><a href="#">651</a></sup>                                              | Raptors/aspergillosis prophylaxis                                                                                                                                                                                                                                                                                                                                                                                                                                  |
|                              | 60 mg/kg PO                                                                                    |                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |

|                                  |                                                                              |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
|----------------------------------|------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                                  | q12h (birds >500 g) <sup><a href="#">11</a></sup>                            | Most species, including galliformes, swans/syringeal aspergilloma                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
|                                  | 75 mg/kg q12h × 5-7 days, then q24h × 14 days <sup><a href="#">651</a></sup> | Raptors/prophylaxis for prevention of aspergillosis; <sup><a href="#">a</a></sup> recommended to treat for 1 wk prior to and 2 wk after move; used routinely for domestically raised gyrfalcons and gyrfalcon hybrids from age 45 days                                                                                                                                                                                                                                                                                |
|                                  | 75-120 mg/kg PO q6h <sup><a href="#">583</a></sup>                           | Most species                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
|                                  | 80-100 mg/kg PO q12h <sup><a href="#">810</a></sup>                          | Ratites                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |
|                                  | 100-250 mg/kg PO q12h <sup><a href="#">402</a></sup>                         | Psittacine neonates                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
|                                  | 120 mg/kg PO q6h <sup><a href="#">397</a></sup>                              | Raptors/aspergillosis                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
|                                  | 150 mg/kg PO q12h (birds <500 g) <sup><a href="#">11</a></sup>               | Most species, including psittacines, galliformes, swans/syringeal aspergilloma                                                                                                                                                                                                                                                                                                                                                                                                                                        |
|                                  | 250 mg/kg PO q12h <sup><a href="#">397</a></sup>                             | Raptors/candidiasis                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
|                                  | 250 mg/kg PO q12h × 14-17 days <sup><a href="#">780</a></sup>                | Finches/endoventricular mycoses; can use with chlorhexidine in drinking water                                                                                                                                                                                                                                                                                                                                                                                                                                         |
|                                  | 50-250 mg/kg feed <sup><a href="#">671,672</a></sup>                         | Psittacines, mynah birds                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
| Griseofulvin                     | 10 mg/kg PO q12h × 21 days <sup><a href="#">63,702</a></sup>                 | Pigeons/dermatophytosis; gavage                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
|                                  | 30-50 mg/kg in drinking water q24h <sup><a href="#">511,810</a></sup>        | Ostriches/mycotic dermatitis                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
| Iodine, 1% solution              | Topical <sup><a href="#">651</a></sup>                                       | Oral or cutaneous candidiasis                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
| Itraconazole (Sporanox, Janssen) | —                                                                            | Most species/systemic mycoses, superficial candidiasis, dermatophytosis; fungistatic; maximal oral bioavailability when taken with a full meal; <sup><a href="#">5</a></sup> commercially available suspension is recommended as a first choice; don't use compounded formulations because bulk drug not bioavailable or stable; <sup><a href="#">93,245</a></sup> study using SC controlled release gel formulation in ducks showed unacceptable tissue and plasma levels of the drug <sup><a href="#">799</a></sup> |
|                                  | 2.5-5 mg/kg PO q24h <sup><a href="#">585,609</a></sup>                       | African grey parrots/anorexia, depression, and toxicity reported at higher doses in this species <sup><a href="#">241</a></sup>                                                                                                                                                                                                                                                                                                                                                                                       |

|  |                                                                                                                 |                                                                                                                                                                                                                    |
|--|-----------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|  | 5 mg/kg PO<br>q24h <sup><a href="#">11</a></sup>                                                                | Galliformes, swans, ratites/aspergillosis                                                                                                                                                                          |
|  | 5-10 mg/kg PO<br>q24h <sup><a href="#">585</a></sup>                                                            | Blue-fronted Amazon parrots/PD; aspergillosis; 10 mg/kg is required to achieve therapeutic concentrations in poorly perfused tissues                                                                               |
|  | 5-10 mg/kg PO<br>q12-24h × 10-14 days, then<br>q48h <sup><a href="#">363</a></sup>                              | Raptors/aspergillosis prophylaxis <sup><a href="#">a</a></sup>                                                                                                                                                     |
|  | 5-10 mg/kg PO<br>q12-24h <sup><a href="#">397</a></sup>                                                         | Raptors                                                                                                                                                                                                            |
|  | 5-10 mg/kg PO<br>q12h × 5 days,<br>followed by q24h<br>for a total of 14<br>days <sup><a href="#">651</a></sup> | Raptors/Class I aspergillosis (mild, vague signs with inconclusive diagnostics or without histologic confirmation)                                                                                                 |
|  | 5-10 mg/kg PO<br>q12h × 5 days,<br>followed by q24h<br>× 60-90 days <sup><a href="#">651</a></sup>              | Raptors/Class II-IV aspergillosis                                                                                                                                                                                  |
|  | 5-10 mg/kg PO<br>q12h <sup><a href="#">409,671</a></sup>                                                        | Passerines (towhees), waterfowl, penguins/aspergillosis prophylaxis in passerines; aspergillosis, candidiasis, cryptococcosis in others                                                                            |
|  | 6 mg/kg PO<br>q12h <sup><a href="#">483</a></sup>                                                               | Pigeons/PD; dosage will achieve fungicidal plasma concentrations                                                                                                                                                   |
|  | 6-8 mg/kg PO<br>q12h × 5-7 days<br>then q24h × 14<br>days <sup><a href="#">651</a></sup>                        | Raptors/prevention of aspergillosis; <sup><a href="#">a</a></sup> recommended to treat for 1 wk prior and 2 wk after move, and routinely for domestically raised gyrfalcons and gyrfalcon hybrids from age 45 days |
|  | 6-10 mg/kg<br>PO <sup><a href="#">384</a></sup>                                                                 | Ratites/preferred azole                                                                                                                                                                                            |
|  | 10 mg/kg PO<br>q24h <sup><a href="#">394,583</a></sup>                                                          | Red-tailed hawks, gentoo penguins/PD; steady state plasma concentrations achieved within 2 wk <sup><a href="#">16</a></sup>                                                                                        |
|  | 10 mg/kg PO<br>q24h × 14-90<br>days with<br>food <sup><a href="#">583,584,609</a></sup>                         | Psittacines/use in combination with non-azoles                                                                                                                                                                     |
|  | 10 mg/kg PO<br>q12-24h <sup><a href="#">584</a></sup>                                                           | Pigeons                                                                                                                                                                                                            |
|  | 10 mg/kg PO<br>q12h × 21-60<br>days <sup><a href="#">147,780</a></sup>                                          | Finches/endoventricular mycoses; can use with chlorhexidine in drinking water                                                                                                                                      |

|                                       |                                                       |                                                                                                                                                                                                                                                                                                                 |
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|                                       | 15 mg/kg PO<br>q12h up to 4-6<br>wk <sup>363</sup>    | Raptors/aspergillosis                                                                                                                                                                                                                                                                                           |
|                                       | 20 mg/kg PO<br>q24h <sup>93</sup>                     | Penguins/PD                                                                                                                                                                                                                                                                                                     |
|                                       | 26 mg/kg PO<br>q12h                                   | Pigeons/PD; fungicidal levels achieved in respiratory tissue; further toxicologic studies are required                                                                                                                                                                                                          |
|                                       | 200 mg/kg feed<br>up to 100 days <sup>663</sup>       | Gouldian finches/PD; dermatomycoses; beads from capsules were mixed with small amount of oil and seed                                                                                                                                                                                                           |
| Ketoconazole<br>(Nizoral,<br>Janssen) | —                                                     | Most species/systemic mycoses (e.g., aspergillosis), candidiasis; fungistatic; less toxic than amphotericin B; more toxic than itraconazole; may be associated with potentially fatal hepatotoxicity; <sup>5</sup> >20 mg/kg may cause regurgitation (if regurgitation, discontinue for 1-2 days, then restart) |
|                                       | 3 mg/kg PO q24h<br>× 7 days <sup>70</sup>             | Pigeons                                                                                                                                                                                                                                                                                                         |
|                                       | 5-10 mg/kg PO<br>q24h <sup>810</sup>                  | Ratites                                                                                                                                                                                                                                                                                                         |
|                                       | 8 mg/kg PO q12h<br>× 30 days <sup>70</sup>            | Ostriches                                                                                                                                                                                                                                                                                                       |
|                                       | 10-20 mg/kg PO<br>q24h <sup>70</sup>                  | Ostriches                                                                                                                                                                                                                                                                                                       |
|                                       | 10-30 mg/kg PO<br>q12h × 30-60<br>days <sup>692</sup> | Most species                                                                                                                                                                                                                                                                                                    |
|                                       | 12.5 mg/kg PO<br>q24h × 30<br>days <sup>672</sup>     | Swans/candidiasis                                                                                                                                                                                                                                                                                               |
|                                       | 15 mg/kg PO<br>q12h <sup>397</sup>                    | Raptors/candidiasis                                                                                                                                                                                                                                                                                             |
|                                       | 20 mg/kg PO<br>q24h × 14<br>days <sup>147</sup>       | Psittacines, passerines, raptors                                                                                                                                                                                                                                                                                |
|                                       | 20 mg/kg PO<br>q12h <sup>402</sup>                    | Psittacine neonates                                                                                                                                                                                                                                                                                             |
|                                       | 20 mg/kg PO q8h<br>× 7-14 days <sup>609</sup>         | Psittacines/refractory candidiasis                                                                                                                                                                                                                                                                              |
|                                       | 20-30 mg/kg PO<br>q8h <sup>238</sup>                  | Cockatoos                                                                                                                                                                                                                                                                                                       |
|                                       | 20-40 mg/kg PO<br>q12h × 15-60                        | Pigeons                                                                                                                                                                                                                                                                                                         |



|            |                                                                                             |                                                                                                                                                                                                                                                                                                                                            |
|------------|---------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|            | days <sup>693</sup>                                                                         |                                                                                                                                                                                                                                                                                                                                            |
|            | 25 mg/kg PO<br>q12h × 14<br>days <sup>702</sup>                                             | Ratites, raptors/aspergillosis                                                                                                                                                                                                                                                                                                             |
|            | 30 mg/kg PO<br>q12h × 7-14<br>days <sup>425</sup>                                           | Amazon parrots/PD                                                                                                                                                                                                                                                                                                                          |
|            | 30 mg/kg PO<br>q12h × 7-30<br>days <sup>425,692</sup>                                       | Pigeons (PD), raptors/prophylactic in raptors for aspergillosis                                                                                                                                                                                                                                                                            |
|            | 50 mg/kg/day<br>PO <sup>150</sup>                                                           | Toucans                                                                                                                                                                                                                                                                                                                                    |
|            | 60 mg/kg PO<br>q12h <sup>838</sup>                                                          | Raptors/PD (common buzzard); aspergillosis                                                                                                                                                                                                                                                                                                 |
|            | 200 mg/L<br>drinking water,<br>nectar, or soft<br>feed × 7-14<br>days <sup>49,198,331</sup> | Canaries, hummingbirds, gouldian finches/dissolve crushed tablet<br>in ½-1 tsp vinegar                                                                                                                                                                                                                                                     |
| Miconazole | —                                                                                           | Fungistatic; inhibits the growth of <i>Candida albicans</i> , <i>Malassezia</i> ,<br>and dermatophytes; injectable miconazole is not available in the<br>United States                                                                                                                                                                     |
|            | 5 mg/kg<br>intratracheal<br>q12h × 5 days <sup>842</sup>                                    | Psittacines/10 mg/mL solution diluted with saline; syringeal<br>mycoses; use with flucytosine; clotrimazole may be an alternative                                                                                                                                                                                                          |
|            | 10 mg/kg IM<br>q24h × 6-12<br>days <sup>702</sup>                                           | Raptors/generalized aspergillosis                                                                                                                                                                                                                                                                                                          |
|            | 20 mg/kg IV<br>q8h <sup>702</sup>                                                           | Psittacines/candidiasis, cryptococcosis                                                                                                                                                                                                                                                                                                    |
|            | Topical to<br>affected areas<br>q12h <sup>651,779</sup>                                     | Cutaneous fungal infections; used in conjunction with oral<br>itraconazole; dermatophytosis                                                                                                                                                                                                                                                |
| Nystatin   | —                                                                                           | Drug of choice for treatment of candidiasis; not systemically<br>absorbed across intact gastrointestinal tract; <sup>5,16</sup> oral lesions must<br>be treated by direct contact with medication; <sup>16</sup> when treating<br>neonates, administer separately from formula to maximize<br>concentration and contact time <sup>16</sup> |
|            | 5000 U/bird PO<br>q12h × 10<br>days <sup>231,232</sup>                                      | Goldfinches/avian gastric yeast; ineffective in budgerigars                                                                                                                                                                                                                                                                                |
|            | 20,000-100,000                                                                              |                                                                                                                                                                                                                                                                                                                                            |

|                                                 |                                                                |                                                                          |
|-------------------------------------------------|----------------------------------------------------------------|--------------------------------------------------------------------------|
|                                                 | U/bird PO q24h × 7 days <a href="#">70,702</a>                 | Pigeons/candidiasis                                                      |
|                                                 | 100,000 U/kg PO q12h <a href="#">322,397</a>                   | Pigeons, raptors                                                         |
|                                                 | 250,000-430,000 U/kg PO q12h <a href="#">147</a>               | Hummingbirds                                                             |
|                                                 | 250,000-500,000 U/kg PO q12h <a href="#">810</a>               | Ratites                                                                  |
|                                                 | 300,000 U/kg PO q12h × 7-14 days <a href="#">63,238</a>        | Most species, including waterfowl                                        |
|                                                 | 300,000-600,000 U/kg PO q8-12h × 7-14 days <a href="#">147</a> | Psittacines                                                              |
|                                                 | 500,000 U/kg PO q8h × 5 days <a href="#">159</a>               | Toucanette (safron)/candidiasis                                          |
|                                                 | Topical q6h <a href="#">368</a>                                | Hummingbirds/candidiasis; direct application using a cotton swab         |
|                                                 | 25,000 U/L nectar <a href="#">368</a>                          | Hummingbirds                                                             |
|                                                 | 100,000 U/L drinking water <a href="#">49,198</a>              | Canaries, finches                                                        |
|                                                 | 200,000 U/kg soft feed <a href="#">49,63</a>                   | Canaries, finches                                                        |
| Parconazole (Parcomyc, Janssen-Cilag)           | 30-60 mg/kg feed <a href="#">680</a>                           | Guinea fowl/candidiasis; prophylaxis; not available in the United States |
| Pimaricin (Natamycin, Alcon)                    | 1 drop in affected eye topically q8h <a href="#">768</a>       | Lovebirds/macrolide antifungal; keratomycosis                            |
| Povidone iodine                                 | Topical to lesions, then rinse <a href="#">63</a>              | Raptors/wound cleansing; antibacterial, antifungal activity              |
| Silver sulfadiazine                             | Topical to affected areas q12-24h <a href="#">228,672</a>      | Most species/bandage application preferred                               |
| STA solution (salicylic acid 3 g, tannic acid 3 | Topical <a href="#">702</a>                                    | Fungal dermatitis                                                        |

|                              |                                                    |                                                                                                                                                                                                                                                                                                                                                                                            |
|------------------------------|----------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| g, ethyl alcohol to 100 mL)  |                                                    |                                                                                                                                                                                                                                                                                                                                                                                            |
| Terbinafine                  | —                                                  | Fungicidal; questionable therapeutic potential for the treatment of aspergillosis in avian species; higher dose or use in combination with itraconazole may be more effective <sup>245</sup>                                                                                                                                                                                               |
|                              | 10-15 mg/kg PO q12-24h <sup>170</sup>              | Most species                                                                                                                                                                                                                                                                                                                                                                               |
|                              | 15 mg/kg PO q24h <sup>53</sup>                     | Penguins/PD                                                                                                                                                                                                                                                                                                                                                                                |
|                              | 15-30 mg/kg PO q12h <sup>245</sup>                 | Most species                                                                                                                                                                                                                                                                                                                                                                               |
|                              | 22 mg/kg PO q24h <sup>54</sup>                     | Raptors/PD                                                                                                                                                                                                                                                                                                                                                                                 |
|                              | 1 mg/mL solution via nebulization <sup>637</sup>   | Most species                                                                                                                                                                                                                                                                                                                                                                               |
| Voriconazole (Vfend, Pfizer) | —                                                  | Most active drug against aspergillosis, although some strains resistant; <sup>55</sup> difficult to extrapolate drug doses between species; safety unproven in birds; PO and IV solutions available; may need to adjust dose for long term treatment to maintain therapeutic concentrations; <sup>245</sup> compounded suspensions stable up to 30 days at room temperature <sup>567</sup> |
|                              | 10 mg/kg PO, IV q12h <sup>95</sup>                 | Chickens/PD                                                                                                                                                                                                                                                                                                                                                                                |
|                              | 10 mg/kg PO q12h or 20 mg/kg q24h <sup>55-57</sup> | Pigeons/PD                                                                                                                                                                                                                                                                                                                                                                                 |
|                              | 12-18 mg/kg PO q12h <sup>254</sup>                 | African grey parrots/PD                                                                                                                                                                                                                                                                                                                                                                    |
|                              | 12.5 mg/kg PO q12h <sup>188,720</sup>              | Raptors                                                                                                                                                                                                                                                                                                                                                                                    |
|                              | 18 mg/kg PO q8h <sup>306</sup>                     | Amazons/PD                                                                                                                                                                                                                                                                                                                                                                                 |
|                              | 20 mg/kg PO q24h × 21 days <sup>595</sup>          | Many species                                                                                                                                                                                                                                                                                                                                                                               |
|                              | 40 mg/kg PO q24h <sup>798</sup>                    | Quail/PD                                                                                                                                                                                                                                                                                                                                                                                   |

<sup>a</sup> Prophylatic use of antifungal agents may be indicated in newly captured or

admitted birds of susceptible species, and in birds undergoing change of management or transfer of enclosure.<sup>651</sup>

TABLE 5-3 Antiviral and Immunomodulating Agents Used in Birds.

| Agent                                                  | Dosage                                                                               | Species/Comments                                                                                                                                                                                                                                                                                                                                                                                                                                                |
|--------------------------------------------------------|--------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Acemannan<br>(Carravet,<br>Carrington<br>Laboratories) | 1 mg/kg SC<br>q7d <sup>857</sup>                                                     | Chemotherapeutic adjunct therapy                                                                                                                                                                                                                                                                                                                                                                                                                                |
|                                                        | 2 mg/kg<br>intralesional<br>q7d × 4<br>treatments <sup>857</sup>                     | Use before surgical debulking of fibrosarcomas                                                                                                                                                                                                                                                                                                                                                                                                                  |
| Acyclovir<br>(Zovirax,<br>Burroughs<br>Wellcome)       | —                                                                                    | Antiviral agent; active against herpesviruses and cytomegalovirus; IM injection of the water-soluble sodium salt (IV formulation) may cause severe muscle necrosis; phlebitis and neurologic signs may occur with IV administration; most effective when administered before clinical signs begin; birds should be treated for a minimum of 7 days; the reconstituted solution is unstable and should be divided into aliquots and frozen <sup>16,702,812</sup> |
|                                                        | 10 mg/kg IM<br>q24h × 5-14<br>days starting 3<br>days<br>postexposure <sup>156</sup> | Chickens/Marek’s disease                                                                                                                                                                                                                                                                                                                                                                                                                                        |
|                                                        | 20-40 mg/kg<br>IM q12h <sup>689</sup>                                                | Psittacines/psittacine herpesvirus                                                                                                                                                                                                                                                                                                                                                                                                                              |
|                                                        | 29 mg/bird PO<br>q8h × 7 days <sup>63</sup>                                          | Pigeons/herpesvirus                                                                                                                                                                                                                                                                                                                                                                                                                                             |
|                                                        | 80 mg/kg PO<br>q8h × 7 days <sup>569</sup>                                           | Quaker parakeets/PD; psittacine herpesvirus prophylaxis or treatment                                                                                                                                                                                                                                                                                                                                                                                            |
|                                                        | 120 mg/kg PO<br>q12h <sup>697</sup>                                                  | Tragopans/PD                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
|                                                        | 330 mg/kg PO<br>q12h × 4-7<br>days <sup>401</sup>                                    | Psittacine neonates/psittacine herpesvirus                                                                                                                                                                                                                                                                                                                                                                                                                      |
|                                                        | 330 mg/kg PO<br>q12h × 7-14<br>days <sup>363</sup>                                   | Raptors/falcon and owl herpesvirus; may cause vomiting                                                                                                                                                                                                                                                                                                                                                                                                          |
|                                                        | ≤400 mg/kg<br>feed <sup>156</sup>                                                    | Quaker parakeets/herpesvirus                                                                                                                                                                                                                                                                                                                                                                                                                                    |

|                                                 |                                                                                                             |                                                                                                                                                                                                                         |
|-------------------------------------------------|-------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                                                 | 1000 mg/L drinking water <sup><a href="#">156,670</a></sup>                                                 | Quaker parakeets/herpesvirus; gavage                                                                                                                                                                                    |
| Amantadine (Symmetrel, Endo Labs)               | —                                                                                                           | Antiviral agent; inhibits replication of influenza A viruses <sup><a href="#">156</a></sup>                                                                                                                             |
|                                                 | 1 mg/kg PO q24h × 3 wk <sup><a href="#">296</a></sup>                                                       | African grey parrots/no effect on avian bornavirus infection                                                                                                                                                            |
|                                                 | 10 mg/kg PO × 3 days pre- and 18 days post-exposure <sup><a href="#">156</a></sup>                          | Turkeys/influenza viruses; must be administered before and during virus exposure                                                                                                                                        |
|                                                 | 25 mg/kg PO × 10 days following infection <sup><a href="#">156</a></sup>                                    | Chickens                                                                                                                                                                                                                |
|                                                 | 100 mg/L drinking water <sup><a href="#">156</a></sup>                                                      | Chickens/can use simultaneously with killed influenza vaccine                                                                                                                                                           |
| Echinacea (Echinacea solution, Biobotania)      | 0.5 mL/kg per L drinking water q24h × 5 days <sup><a href="#">702</a></sup>                                 | Psittacines/herbal immunostimulant                                                                                                                                                                                      |
|                                                 | 1 mL/L drinking water <sup><a href="#">671</a></sup>                                                        | Psittacines; use alcohol-free formulation                                                                                                                                                                               |
| Famciclovir (Famvir, Novartis)                  | 25 mg/kg PO q12h <sup><a href="#">807</a></sup>                                                             | Ducklings/PD; antiviral agent; duck hepatitis; toxic effects were not reported                                                                                                                                          |
| Imiquimod cream (Aldara, 3M)                    | Applied topically 3×/wk several hr before the morning feeding <sup><a href="#">451</a></sup>                | Psittacines/cloacal papillomatosis; thought to boost host cell-mediated immunity; masses decreased in size in one report, but not in another; <sup><a href="#">447</a></sup> complete remission did not occur in either |
| ImmunoRegulin (Propionibacterium Acnes, Neogen) | 0.13 mg/kg (up to 0.08 mg [0.2 mL] max) SC, IM days 1,3,7,14,28,42, then q30d <sup><a href="#">45</a></sup> | Psittacines/immune therapy for chronic feather pickers; induces macrophage and lymphokine production; enhances cell-mediated immunity; increases natural killer cell activity; do not use with corticosteroids          |
| Interferon $\alpha_{2a}$                        | —                                                                                                           | Glycoprotein with immunomodulating and antiproliferative capabilities as well as antiviral activity                                                                                                                     |
|                                                 |                                                                                                             |                                                                                                                                                                                                                         |

|                                 |                                                                            |                                                                                                                                                                                                        |
|---------------------------------|----------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                                 | 30 U q24h × 5 days, 30 U 2×/wk × 2 wk, then 30 U q7d × 2 wk <sup>299</sup> | Most species/proventricular dilatation disease; may be associated with temporary clinical improvement                                                                                                  |
|                                 | 60-240 U/kg SC, IM q12h <sup>733</sup>                                     | Most species/stock solution: mix 1 mL (3,000,000 U/mL) with 100 mL sterile water (30,000 U/mL); can freeze as 2 mL vials up to 1 yr; mix 2 mL of stock into 1 L LRS (=60 U/mL); refrigerate up to 3 mo |
|                                 | 1500 U/kg PO q24h <sup>16</sup>                                            | Psittacines                                                                                                                                                                                            |
|                                 | 1,000,000 U IM q48h to q7d × 3 treatments <sup>762</sup>                   | African grey parrots/circovirus; omega alpha-2 interferon                                                                                                                                              |
|                                 | 1000 U/L drinking water × 14-28 days <sup>691</sup>                        | Pigeons/circovirus                                                                                                                                                                                     |
| Levamisole                      | —                                                                          | Anthelmintic with immunostimulation properties; low therapeutic index (toxic reactions and deaths reported)                                                                                            |
|                                 | 1.25-2.5 mg/kg PO, SC <sup>670</sup>                                       | Poultry                                                                                                                                                                                                |
|                                 | 2 mg/kg SC, IM q14d × 3 treatments <sup>87,672</sup>                       | Most species, including macaws                                                                                                                                                                         |
|                                 | 11 mg/L drinking water × 3-5 wk <sup>133</sup>                             | Most species                                                                                                                                                                                           |
| Penciclovir (Denavir, Novartis) | 10 mg/kg IP q24h × 12-24 wk <sup>465</sup>                                 | Ducks/PD; antiviral agent active against herpesviruses; duck hepatitis B virus; viral levels were significantly reduced; no toxic effects observed; dissolve in 2 mL of 1% DMSO                        |
| Rimantadine (Flumadine, Forest) | 100 mg/L drinking water <sup>156</sup>                                     | Chickens/influenza viruses; must be used before and during exposure                                                                                                                                    |
| Silymarin (milk thistle)        | 100-150 mg/kg PO divided q8-12h <sup>11</sup>                              | Most species/hepatic antioxidant; used in patients with liver disease and as ancillary to chemotherapy; use an alcohol-free liquid formulation                                                         |
| Vitamin C (ascorbic acid)       | 20-50 mg/kg IM q1-7d <sup>397,672</sup>                                    | Most species, including raptors/antioxidant; immunostimulant; nutritional support; acidify the gut                                                                                                     |

TABLE 5-4 Antiparasitic Agents Used in Birds.

| Agent | Dosage | Species/Comments |
|-------|--------|------------------|
|-------|--------|------------------|

|                                                 |                                                                                                                              |                                                                                                                                                                                                                    |
|-------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Albendazole (11.36%) (Valbazen, Pfizer)         | —                                                                                                                            | Broad-spectrum anthelmintic; may be toxic in keas, some Columbiformes at 50-100 mg/kg <sup>361,759</sup>                                                                                                           |
|                                                 | 5.2 mg/kg PO q12h × 3 days, repeat in 14 days <sup>810</sup>                                                                 | Ratites/flagellates, cestodes                                                                                                                                                                                      |
|                                                 | 10 mg/kg PO once <sup>158</sup>                                                                                              | Poultry/PK                                                                                                                                                                                                         |
|                                                 | 15-20 mg/kg PO once <sup>150</sup>                                                                                           | Toucans                                                                                                                                                                                                            |
|                                                 | 25 mg/kg PO q24h × 90 days, then repeat × 120 days when signs returned <sup>612</sup>                                        | Cockatoos/ <i>Encephalitozoon hellem</i> keratoconjunctivitis                                                                                                                                                      |
|                                                 | 25-50 mg/kg PO q24h × 3-4 days <sup>759</sup>                                                                                | Doves, rock partridges/ <i>Capillaria</i>                                                                                                                                                                          |
|                                                 | 47 mg/kg PO once, then repeat in 4 wk <sup>743</sup>                                                                         | Chickens/lower ascarid, <i>Heterakis</i> fecal counts then nontreated                                                                                                                                              |
|                                                 | 50 mg/kg PO q24h × 5 days <sup>108</sup>                                                                                     | Amazon parrots/microsporidian keratoconjunctivitis                                                                                                                                                                 |
|                                                 | 113-116 mg/23 kg q12h × 3 days, repeat in 14 wk <sup>43</sup>                                                                | Ratites/protozoal infections                                                                                                                                                                                       |
| Amitraz (Mitaban, Upjohn)                       | —                                                                                                                            | Highly effective against <i>Dermanyssus gallinae</i> <sup>504</sup>                                                                                                                                                |
|                                                 | Spray 2.5 L/bird with 0.025% solution (dilute 1 part amitraz [12.5%] with 500 parts water), repeat in 10 days <sup>102</sup> | Ostriches/lice                                                                                                                                                                                                     |
| Amprolium (Corid, TEVA; Amprol Plus MSD, AgVet) | —                                                                                                                            | Pyrimidine derivative coccidiostat; although rarely encountered, efficacy can be reduced by high doses of thiamine; <sup>757</sup> some coccidial organisms of mynahs, toucans have shown resistance <sup>43</sup> |
|                                                 | 2.2 mg/kg PO <sup>115</sup>                                                                                                  | Sandhill cranes/ineffective in preventing experimentally induced disseminated visceral coccidiosis                                                                                                                 |
|                                                 | 13-26 mg/kg PO <sup>308</sup>                                                                                                | Chickens/PK,PD; bioavailability almost 4 times greater in fasted birds                                                                                                                                             |

|                                                  |                                                                    |                                                                                                               |
|--------------------------------------------------|--------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------|
|                                                  | 25 mg/kg/day PO <sup>43</sup>                                      | Pigeons                                                                                                       |
|                                                  | 30 mg/kg PO q24h × 5 days <sup>43,341</sup>                        | Raptors                                                                                                       |
|                                                  | 5-100 mg/L drinking water × 5-7 days <sup>43</sup>                 | Most species/flock treatm                                                                                     |
|                                                  | 50-100 mg/L drinking water × 5-7 days <sup>173,506</sup>           | Most species, including passerines, parakeets                                                                 |
|                                                  | 60 mg/L drinking water <sup>111</sup>                              | Cranes                                                                                                        |
|                                                  | 200 mg/L drinking water <sup>323,324</sup>                         | Pigeons/flock treatment                                                                                       |
|                                                  | 250 mg/L drinking water × 7 days <sup>843</sup>                    | Psittacines (keas)/ <i>Sarcocystis</i> ; use in combination with pyrimethamine and primaquine                 |
|                                                  | 575 mg/L drinking water <sup>119</sup>                             | Poultry/using a 9.6% solution                                                                                 |
|                                                  | ¼ tsp/L drinking water × 3-5 days <sup>320,321</sup>               | Pigeons, poultry/20% soluble powder                                                                           |
|                                                  | 115-235 mg/kg feed <sup>113,757</sup>                              | Poultry, pheasants, cranes/coccidia; <i>Sarcocys</i> ; lower dose is prophylactic; higher dose is therapeutic |
|                                                  | 125 mg/kg feed <sup>647</sup>                                      | Turkeys/31/33 <i>Eimeria</i> isolates resistant                                                               |
| Cambendazole (Equiben, MSD, AgVet)               | 60-100 mg/kg PO q24h × 3-7 days <sup>506</sup>                     | Most species                                                                                                  |
|                                                  | 75 mg/kg PO q24h × 2 days <sup>43,325</sup>                        | Pigeons                                                                                                       |
| Carbaryl 5% (Sevin Dust, Bayer)                  | Topical; light dusting of plumage or nest box litter <sup>43</sup> | Most species/ants, ectoparasites; remove the litter after 24 hr                                               |
|                                                  | 1-2 tsp to nesting material <sup>43</sup>                          | Most species/ectoparasite control                                                                             |
| Carnidazole (Spartrix, Wildlife Pharmaceuticals) | —                                                                  | Treatment for <i>Trichomonas</i> , <i>Hexamita</i> , <i>Histomonas</i> <sup>43</sup>                          |
|                                                  | 5 mg/bird PO <sup>693</sup>                                        | Doves (adults), pigeons (squabs)                                                                              |
|                                                  | 10 mg/bird PO <sup>785</sup>                                       | Pink pigeons (adults)/ <i>Trichomonas</i> ; squabs ≤18 days old administer 5 mg                               |
|                                                  | 12.5-25 mg/kg PO once <sup>43,126</sup>                            | Pigeons/ <i>Trichomonas</i> , use lower dose with juvenile birds; combine with                                |



|                       |                                                                                     |                                                                                                                                                              |
|-----------------------|-------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                       |                                                                                     | dimetridazole to treat flo                                                                                                                                   |
|                       | 20 mg/kg PO once <sup><a href="#">324</a></sup>                                     | Pigeons                                                                                                                                                      |
|                       | 20 mg/kg q24h PO × 2 days <sup><a href="#">341,397</a></sup>                        | Raptors                                                                                                                                                      |
|                       | 20-25 mg/kg PO once <sup><a href="#">43</a></sup>                                   | Raptors/single dose not always effective in falcor bustards with advanced infections                                                                         |
|                       | 20-30 mg/kg PO q24h × 1-2 days <sup><a href="#">43,126</a></sup>                    | Most species, including pigeons, psittacines                                                                                                                 |
|                       | 20-30 mg/kg PO q24h × 5 days <sup><a href="#">28</a></sup>                          | House finches/reliably cleared <i>Trichomonas gallinae</i> if caught prior to clinical signs                                                                 |
|                       | 30 mg/kg PO once <sup><a href="#">261</a></sup>                                     | Raptors/ <i>Trichomonas</i>                                                                                                                                  |
|                       | 30 mg/kg PO q12h × 3 days <sup><a href="#">392</a></sup>                            | Raptors                                                                                                                                                      |
|                       | 30 mg/kg PO q24h × 3 days <sup><a href="#">660</a></sup>                            | Raptors/ <i>Trichomonas</i>                                                                                                                                  |
|                       | 30-50 mg/kg PO, repeat in 10-14 days <sup><a href="#">387,672</a></sup>             | Cockatiels/ <i>Giardia</i>                                                                                                                                   |
|                       | 33 mg/kg PO, repeat in 14 and 28 days <sup><a href="#">49</a></sup>                 | Society finches, Gouldian finches/flagellates; 0.5 mg/adult (based on 15 g); 0.25 mg/nestling (based on 7.5 g)                                               |
|                       | 50 mg/kg PO once <sup><a href="#">363</a></sup>                                     | Raptors                                                                                                                                                      |
|                       | 120 mg/kg PO as single dose or divided over 2-5 days <sup><a href="#">817</a></sup> | American kestrels, screech owls/ <i>Trichomonas</i> infections resistant to treatment with lower doses                                                       |
| Chloroquine phosphate | —                                                                                   | Generally used with primaquine for <i>Plasmodium</i> , <i>Haemoproteus</i> and <i>Leucocytozoon</i> ; overdose result in death <sup><a href="#">43</a></sup> |
|                       | 5 mg/kg PO q24h or in feed <sup><a href="#">672,757</a></sup>                       | Game birds, penguins/in penguins, precede treatment with primaquine by 6 hr                                                                                  |
|                       | 10 mg/kg PO q7d <sup><a href="#">661</a></sup>                                      | Most species/preventative treatment for <i>Plasmodium</i> once bird is stable; use with primaquine (1 mg/kg q7d)                                             |
|                       | 10 mg/kg PO, then 5 mg/kg at 6, 18,                                                 | Penguins                                                                                                                                                     |

|                                         |                                                                                                        |                                                                                                                               |
|-----------------------------------------|--------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------|
|                                         | and 24 hr <sup>43</sup><br>10 mg/kg PO, then 5 mg/kg at 6, 24,<br>and 48 hr <sup>113</sup>             | Raptors/use with 0.3 mg/<br>primaquine (at 24 hr<br>following the initial<br>chloroquine dose) q24h ×<br>days                 |
|                                         | 20 mg/kg PO or IV, then 10 mg/kg at 6,<br>18, and 24 hr; repeat q7d × 3-5<br>treatments <sup>671</sup> | Raptors/ <i>Plasmodium</i> ; IV<br>recommended for initial<br>dose in acute cases; use v<br>1 mg/kg primaquine q24h<br>2 days |
|                                         | 25 mg/kg PO, then 15 mg/kg PO at 12,<br>24, and 48 hr <sup>665,747</sup>                               | Most species, including<br>raptors/use with 0.75-1.3<br>mg/kg primaquine at 0 hr                                              |
|                                         | 60 mg/kg PO q24h × 7 days <sup>551</sup>                                                               | Raptors/ <i>Haemoproteus</i> ; u<br>in conjunction with<br>mefloquine and primaqui                                            |
|                                         | 2000 mg/L drinking water q24h × 14<br>days <sup>126,757</sup>                                          | Passerines, game birds/ju<br>covers bitter taste of drug                                                                      |
| Clazuril (Appertex, Janssen)            | —                                                                                                      | Benzene-acetonitrile<br>anticoccidial                                                                                         |
|                                         | 2.5 mg/bird PO once; can repeat<br>monthly <sup>830</sup>                                              | Pigeons/oocyst shedding<br>commences 20 days post-<br>treatment                                                               |
|                                         | 3 mg/kg PO once, or × 5 days <sup>288</sup>                                                            | Chickens/PK; drug detect<br>in eggs after multiple dos                                                                        |
|                                         | 5 mg/kg PO once <sup>126</sup>                                                                         | Pigeons                                                                                                                       |
|                                         | 5-10 mg/kg PO q24h × 2 days <sup>341</sup>                                                             | Raptors                                                                                                                       |
|                                         | 5-10 mg/kg PO q24h × 3 days, off 2<br>days, on 3 days <sup>506</sup>                                   | Poultry, pigeons                                                                                                              |
|                                         | 5-10 mg/kg PO q72h × 3<br>treatments <sup>43,149</sup>                                                 | Waterfowl, raptors                                                                                                            |
|                                         | 6.25 mg/kg PO once <sup>43</sup>                                                                       | Pigeons                                                                                                                       |
|                                         | 7 mg/kg PO × 3 days, off 2 days, on 3<br>days <sup>43,64</sup>                                         | Psittacines                                                                                                                   |
|                                         | 30 mg/kg PO once <sup>126</sup>                                                                        | Raptors                                                                                                                       |
|                                         | 1.1 or 5.5 mg/kg feed <sup>115</sup>                                                                   | Sandhill cranes/ineffectiv<br>in preventing experiment<br>induced disseminated<br>visceral coccidiosis                        |
| Clopidol (25%) (Coyden-25,<br>Alpharma) | 125 mg/kg feed <sup>647</sup>                                                                          | Turkeys/16/33 <i>Eimeria</i><br>isolates showed partial to                                                                    |

|                                                                           |                                                                                                          |                                                                                                                                                                                                           |
|---------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                                                                           | 125-250 mg/kg feed <sup><a href="#">757</a></sup>                                                        | complete resistance<br>Game birds/coccidiosis,<br><i>Leucocytozoon</i> , <i>Plasmodi</i>                                                                                                                  |
| Clorsulon (Curatrem, Merial)                                              | —                                                                                                        | Benzenesulfonamide<br>anthelmintic and flukicid                                                                                                                                                           |
|                                                                           | 20 mg/kg PO q14d × 3<br>treatments <sup><a href="#">43</a>,<a href="#">141</a>,<a href="#">671</a></sup> | Psitacines, waterfowl,<br>raptors/trematodes, cesto                                                                                                                                                       |
|                                                                           | 20 mg/kg PO 3×/wk × 14 days <sup><a href="#">63</a></sup>                                                | Waterfowl,<br>raptors/trematodes, cesto                                                                                                                                                                   |
| Crotamiton (Eurax, Westwood-Squibb)                                       | Topical to affected areas <sup><a href="#">43</a></sup>                                                  | Most species/mites (i.e.,<br><i>Knemidokoptes</i> ); use in<br>combination with iverme                                                                                                                    |
| Cypermethrin (5%) (Max Con, Y-<br>Tex)                                    | 60-120 mg/chicken topically over<br>dorsal neck <sup><a href="#">21</a></sup>                            | Chickens/effective against<br><i>Triatoma infestans</i>                                                                                                                                                   |
|                                                                           | Spray or dip with 1:100 dilution <sup><a href="#">43</a></sup>                                           | Pigeons, ostriches/lice, m                                                                                                                                                                                |
| Decoquate (Deccox, Alpharma)                                              | 20-40 mg/kg feed <sup><a href="#">304</a>,<a href="#">787</a></sup>                                      | Chickens/ <i>Eimeria</i> ; very<br>effective in isolates studi                                                                                                                                            |
| Deltamethrin (Spot On, Schering-<br>Plough)                               | 50 mg/L topical spray <sup><a href="#">511</a></sup>                                                     | Ostriches/lice; spray until<br>runoff                                                                                                                                                                     |
| Dichlorophene (Tapeworm tablets,<br>Happy Jack)                           | 100 mg PO q10d × 2 treatments, repeat<br>in 10 days prn <sup><a href="#">417</a></sup>                   | Pigeons/cestodes; admini<br>after a 12-hr fast                                                                                                                                                            |
| Diclazuril (Clinicox 0.5%,<br>Huvepharma AD; DiClosol 1%,<br>Pharmaswede) | —                                                                                                        | Benzene-acetonitrile<br>anticoccidial; some <i>Eime</i><br>resistance in poultry<br>documented recently; <sup><a href="#">4</a>,<a href="#">64</a></sup><br>rotation suggested for lon<br>term prevention |
|                                                                           | 10 mg/kg PO q12h on days<br>0,1,2,4,6,8,10 <sup><a href="#">514</a></sup>                                | Hawaiian crows/ <i>Toxoplas</i>                                                                                                                                                                           |
|                                                                           | 5 mg/L drinking water × 6 days <sup><a href="#">33</a></sup>                                             | Chickens/reduced oocyst<br>viability and virulence                                                                                                                                                        |
|                                                                           | 5-10 mg/L drinking water × 2 days <sup><a href="#">213</a></sup>                                         | Chickens/effective in<br>preventing disease and<br>reducing total oocysts,<br>lesions and mortality in<br>infected birds with mixed<br><i>Eimeria</i> infections                                          |
|                                                                           | 0.5-1 mg/kg feed <sup><a href="#">123</a>,<a href="#">213</a></sup>                                      | Chickens, turkeys/coccid                                                                                                                                                                                  |
|                                                                           | 1 mg/kg feed <sup><a href="#">647</a></sup>                                                              | Turkeys/21/33 <i>Eimeria</i><br>isolates partially or<br>completely resistant                                                                                                                             |
|                                                                           |                                                                                                          | <i>Trichomonas</i> , <i>Giardia</i> ,                                                                                                                                                                     |

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| Dimetridazole (Emtryl 40% powder, Rhone Merieux) |                                                                                | <i>Hexamita</i> , <i>Spironucleus</i> , <i>Histomonas</i> ; low therapeutic index; hepatotoxic to lories and some passerines (e.g., robins) and fledgling birds; not recommended for finches; highly toxic to geese, ducks, and pigeons; not available in many countries (United States, European Union) because of human health risks; Canada has banned use in food-producing animals; <sup>561</sup> do not give during breeding season <sup>43</sup> |
|                                                  | 50 mg/kg PO q24h × 10 days <sup>543</sup>                                      | Falcons/ <i>Enterocytozoon bieneusi</i>                                                                                                                                                                                                                                                                                                                                                                                                                  |
|                                                  | 50 mg/kg PO or in drinking water q24h × 6 days <sup>126</sup>                  | Pigeons                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
|                                                  | 100 mg/L drinking water <sup>198</sup>                                         | Canaries, finches                                                                                                                                                                                                                                                                                                                                                                                                                                        |
|                                                  | 200-400 mg/L drinking water × 5 days <sup>13,70</sup>                          | Psittacines, game birds                                                                                                                                                                                                                                                                                                                                                                                                                                  |
|                                                  | 250 mg/L drinking water × 4-6 days <sup>49</sup>                               | Gouldian finches/ <i>Cochlostoma</i> , <i>Trichomonas</i>                                                                                                                                                                                                                                                                                                                                                                                                |
|                                                  | 265 mg/L drinking water <sup>102</sup>                                         | Pigeons                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
|                                                  | 300 mg/L drinking water × 10 days <sup>43</sup>                                | Bustards/prevention of <i>Trichomonas</i>                                                                                                                                                                                                                                                                                                                                                                                                                |
|                                                  | 400 mg/L drinking water × 3 days <sup>367</sup>                                | Pigeons/PD; bioavailability reduced with feed                                                                                                                                                                                                                                                                                                                                                                                                            |
|                                                  | 666 mg/L drinking water × 7-12 days <sup>43</sup>                              | Pigeons/ <i>Trichomonas</i> , <i>Giardia</i> , <i>Hexamita</i>                                                                                                                                                                                                                                                                                                                                                                                           |
|                                                  | 800 mg/L drinking water <sup>757</sup>                                         | Poultry, game birds                                                                                                                                                                                                                                                                                                                                                                                                                                      |
|                                                  | 900 mg/L drinking water × 5 days, followed by 700 mg/L × 10 days <sup>43</sup> | Bustards/treatment of choice for <i>Trichomonas</i>                                                                                                                                                                                                                                                                                                                                                                                                      |
|                                                  | ¼-½ tsp/gal drinking water × 3-5 days <sup>323</sup>                           | Pigeons/CNS symptoms if overdosed; because of variable water consumption, use lower dose in hot weather and higher dose in cool weather                                                                                                                                                                                                                                                                                                                  |
|                                                  | ½ tsp/gal drinking water × 5 days <sup>671</sup>                               | Lories, mynahs                                                                                                                                                                                                                                                                                                                                                                                                                                           |

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|                                  | 1 tsp/gal drinking water × 5 days <sup>506,518</sup>           | Most species                                                                                                                                                                                                                                                                                                                                                                                                                                         |
|                                  | 185-187.5 mg/kg feed <sup>102,757</sup>                        | Poultry, game birds                                                                                                                                                                                                                                                                                                                                                                                                                                  |
|                                  | 200-400 mg/kg feed <sup>362</sup>                              | Chickens/highly effective against <i>Histomonas</i>                                                                                                                                                                                                                                                                                                                                                                                                  |
|                                  | 200-500 mg/kg feed <sup>102</sup>                              | Ostriches (≤3 mo of age)/ <i>Trichomonas</i>                                                                                                                                                                                                                                                                                                                                                                                                         |
|                                  | 250 mg/kg feed <sup>43</sup>                                   | Bustards/ <i>Trichomonas</i>                                                                                                                                                                                                                                                                                                                                                                                                                         |
| Dinitolmide (Zoamix, Alpharma)   | 40-187 mg/kg feed <sup>511</sup>                               | Chickens, turkeys/coccid                                                                                                                                                                                                                                                                                                                                                                                                                             |
| Doramectin (Dectomax, Pfizer)    | 1 mg/kg SC, IM, <sup>43</sup> repeat in 2 weeks <sup>126</sup> | Raptors, bustards/used to treat GI nematodes, lungworms, eyeworms, mites <sup>43</sup>                                                                                                                                                                                                                                                                                                                                                               |
| Febantel (Vercom, Rintal, Bayer) | 5 mg/kg PO <sup>511</sup>                                      | Ostriches                                                                                                                                                                                                                                                                                                                                                                                                                                            |
|                                  | 20 mg/kg PO <sup>511</sup>                                     | Ostriches                                                                                                                                                                                                                                                                                                                                                                                                                                            |
|                                  | 30 mg/kg PO once <sup>41</sup>                                 | Pigeons/PD; ascarids; repeated doses required to eliminate <i>Capillaria obsignata</i>                                                                                                                                                                                                                                                                                                                                                               |
|                                  | 37.5 mg/kg PO once <sup>43</sup>                               | Pigeons                                                                                                                                                                                                                                                                                                                                                                                                                                              |
| Fenbendazole (Panacur, Intervet) | —                                                              | Most species/anthelmintic effective against cestodes, nematodes, trematodes, <i>Giardia</i> , acanthocephalar; toxicity documented in pigeons and doves; <sup>361,594</sup> may be toxic for other species, including raptors, vultures, <sup>75,363</sup> lorries, <sup>594</sup> storks; <sup>75,839</sup> can cause feather abnormalities if administered during molting; <sup>43</sup> ineffective against finch ventricular worms <sup>43</sup> |
|                                  | 1.5-3.9 mg/kg PO q24h × 3 days <sup>793</sup>                  | Chickens/PK, PD; <i>Capill</i>                                                                                                                                                                                                                                                                                                                                                                                                                       |
|                                  | 8 mg/bird PO once <sup>43,126</sup>                            | Pigeons/(>8 wk old)                                                                                                                                                                                                                                                                                                                                                                                                                                  |
|                                  | 10-20 mg/kg PO q24h × 3 days <sup>126,324</sup>                | Pigeons/nematodes                                                                                                                                                                                                                                                                                                                                                                                                                                    |
|                                  | 10-50 mg/kg PO, repeat in 14 days <sup>363,397</sup>           | Raptors/nematodes, trematodes                                                                                                                                                                                                                                                                                                                                                                                                                        |
|                                  |                                                                | Partridges,                                                                                                                                                                                                                                                                                                                                                                                                                                          |

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|  | 12 mg/kg PO <sup><a href="#">102</a></sup>                                                                       | pheasants/ <i>Syngamus</i> ,<br><i>Heterakis</i> , <i>Ascaridia</i>                                                                                                     |
|  | 15 mg/kg PO <sup><a href="#">388</a></sup>                                                                       | Ostriches/“wire worms”,<br>cestodes                                                                                                                                     |
|  | 15 mg/kg PO q24h × 5 days <sup><a href="#">43</a></sup>                                                          | Psittacines                                                                                                                                                             |
|  | 15-25 mg/kg PO × 4-5 days <sup><a href="#">737</a></sup>                                                         | Tinamous                                                                                                                                                                |
|  | 15-45 mg/kg PO <sup><a href="#">102</a></sup>                                                                    | Ostriches                                                                                                                                                               |
|  | 20 mg/kg PO once <sup><a href="#">43,834</a></sup>                                                               | Waterfowl,<br>pheasants/cestodes,<br>nematodes,<br>acanthocephalans; reduce<br><i>Heterakis</i> and <i>Eimeria</i> in<br>pheasants                                      |
|  | 20 mg/kg PO q24h × 10-14 days <sup><a href="#">149</a></sup>                                                     | Raptors/filarids                                                                                                                                                        |
|  | 20-25 mg/kg PO q24h × 5<br>days <sup><a href="#">149,261,657</a></sup>                                           | Raptors/ <i>Capillaria</i>                                                                                                                                              |
|  | 20-50 mg/kg PO q24h <sup><a href="#">43,812</a></sup>                                                            | Psittacines, pigeons/ascari<br>in psittacines, treat once ;<br>repeat in 10 days; tremato<br>and microfilaria, treat for<br>days; <i>Capillaria</i> , treat for<br>days |
|  | 20-50 mg/kg q24h × 3 days, repeat in<br>21 days <sup><a href="#">363</a></sup>                                   | Raptors                                                                                                                                                                 |
|  | 20-100 mg/kg PO once <sup><a href="#">506</a></sup>                                                              | Most species                                                                                                                                                            |
|  | 25 mg/kg PO, repeat in 14 days <sup><a href="#">141,746</a></sup>                                                | Most species, including<br>owls/ascarids                                                                                                                                |
|  | 25 mg/kg PO q24h × 5 days, <sup><a href="#">126</a></sup> repeat<br>in 10-14 days <sup><a href="#">363</a></sup> | Raptors/ <i>Capillaria</i> , spiru                                                                                                                                      |
|  | 30 mg/kg PO once <sup><a href="#">43</a></sup>                                                                   | Bustards                                                                                                                                                                |
|  | 33 mg/kg PO q24h × 3 days <sup><a href="#">147</a></sup>                                                         | Psittacines, passerines,<br>raptors/microfilaria,<br>trematodes                                                                                                         |
|  | 50 mg/kg PO q24h × 3 days <sup><a href="#">141,571,693</a></sup>                                                 | Most species, including<br>pigeons, Bali<br>mynahs/nematodes,<br>trematodes, <i>Giardia</i>                                                                             |
|  | 50 mg/kg PO q24h × 5 days <sup><a href="#">141</a></sup>                                                         | Most species/ <i>Capillaria</i>                                                                                                                                         |
|  | 50 mg/kg PO q12h × 5 days <sup><a href="#">692</a></sup>                                                         | Cockatoos/filarid adultici<br>treatment; use with<br>ivermectin (0.2 mg/kg on                                                                                           |
|  |                                                                                                                  |                                                                                                                                                                         |

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|                                                           | 100 mg/kg PO once, repeat in 10-14 days <sup>363</sup>                     | Raptors/ <i>Capillaria</i> , spiru                                                                                                                                                                                            |
|                                                           | 100 mg/kg PO q24h × 5 days <sup>111</sup>                                  | Cranes/ <i>Capillaria</i>                                                                                                                                                                                                     |
|                                                           | 50 mg/L drinking water × 5 days <sup>506</sup>                             | Finches                                                                                                                                                                                                                       |
|                                                           | 125 mg/L drinking water × 5 days <sup>506</sup>                            | Most species/nematodes                                                                                                                                                                                                        |
|                                                           | 53 mg/kg in feed × 5-7 days <sup>757</sup>                                 | Game birds/nematodes, trematodes                                                                                                                                                                                              |
|                                                           | 80 mg/kg feed <sup>793</sup>                                               | Chickens/PK, PD; <i>Capill</i>                                                                                                                                                                                                |
| Fipronil (Frontline, Merial)                              | 7.5 mg/kg; spray on skin once, repeat in 30 days prn <sup>43,126,261</sup> | Raptors, pigeons, passerines/ectoparasites; apply via pad to base of neck, tail base, and under each wing; avoid plumage during application; alcohol may create dry, brittle feathers; do not soak bird; not exceed 7.5 mg/kg |
| Flubendazole (Flutelmium 7.5%, Janssen-Cilag)             | 30-60 mg/kg feed × 7 days <sup>737</sup>                                   | Tinamous                                                                                                                                                                                                                      |
|                                                           | 60 mg/kg feed × 7-14 days <sup>102,146</sup>                               | Partridges, pheasants                                                                                                                                                                                                         |
| Halofuginone (Collgard Biopharmaceuticals)                | —                                                                          | Not available in the United States                                                                                                                                                                                            |
|                                                           | 1.3-2.72 mg/kg feed <sup>119</sup>                                         | Turkeys/coccidia; not approved for birds intended for food                                                                                                                                                                    |
|                                                           | 2.7 mg/kg feed <sup>119</sup>                                              | Chickens/coccidia, <i>Plasmodium</i>                                                                                                                                                                                          |
| Hydroxychloroquine sulfate (Plaquenil, Sanofi Winthrop)   | —                                                                          | Antimalarial                                                                                                                                                                                                                  |
|                                                           | 830 mg/L drinking water × 6 wk <sup>387</sup>                              | Pigeons/ <i>Plasmodium</i>                                                                                                                                                                                                    |
| Hygromycin B (Hygromix 8, Elanco)                         | —                                                                          | Aminoglycoside antibiotic used as anthelmintic feed additive                                                                                                                                                                  |
|                                                           | 9-13 mg/kg feed <sup>757</sup>                                             | Game birds/ascarids, cecal worms; some efficacy against <i>Capillaria</i>                                                                                                                                                     |
|                                                           | 18-26 mg/kg feed × 2 mo <sup>757</sup>                                     | Game birds/cecal worms                                                                                                                                                                                                        |
| Imidocarb dipropionate (Imizol, Intervet/Schering-Plough) | —                                                                          | Antiprotozoal effective against <i>Babesia</i>                                                                                                                                                                                |
|                                                           | 5-7 mg/kg IM once, repeat in 7 days <sup>709,850</sup>                     | Raptors/ <i>Babesia</i> ; some cases require a total of 3 treatments                                                                                                                                                          |
|                                                           |                                                                            | <i>Giardia</i> , <i>Trichomonas</i> , <i>Histomonas</i> ; not available                                                                                                                                                       |



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| Iprnidazole (Ipropran, Roche) | —                                                                                                             | the United States; 61 g/2. oz                                                                                                                                                                                                                                                                                                                                                             |
|                               | 130 mg/L drinking water × 7 days <a href="#">37,506</a>                                                       | Most species, including pigeons                                                                                                                                                                                                                                                                                                                                                           |
|                               | 250 mg/L drinking water × 3-7 days <a href="#">518,693</a>                                                    | Psittacines, pigeons                                                                                                                                                                                                                                                                                                                                                                      |
| Ivermectin (Ivomec, Merial)   | —                                                                                                             | All species/most nematoc acanthocephalans, leeches most ectoparasites (including <i>Knemidokoptes</i> <i>Dermanyssus</i> ); can dilute with water or saline for immediate use; dilute with propylene glycol for extended use; parenteral ivermectin may be toxic to finches and budgerigars; <sup>1</sup> suspected toxicity reported in a Nanday conure at 0.2 mg/kg <a href="#">605</a> |
|                               | 0.2 mg/kg PO, SC, IM once, can repeat in 10-14 days <a href="#">43,63,111,126,323,324,355,384,581,692,757</a> | Most species, including psittacines, passerines, pigeons, raptors, Guinea fowl, waterfowl, ratites, cranes/use in combination with fenbendazole at 50 mg/kg PO q12h × 5 days microfilaria in cockatoos                                                                                                                                                                                    |
|                               | 0.2 mg/kg SC, topical on skin; can repeat 1-2 weeks for 3-4 applications <a href="#">126,173,203</a>          | Canaries/quill mites, <i>Knemidokoptes</i> ; dilute to 0.02% solution with propylene glycol; can apply directly to lesions on cere and legs                                                                                                                                                                                                                                               |
|                               | 0.4 mg/kg SC once <a href="#">409</a>                                                                         | Passerines (towhees)/ <i>Capillaria</i>                                                                                                                                                                                                                                                                                                                                                   |
|                               | 0.4 mg/kg SC once <a href="#">506</a>                                                                         | Raptors                                                                                                                                                                                                                                                                                                                                                                                   |
|                               | 0.5-1 mg/kg PO, IM once <a href="#">323</a>                                                                   | Pigeons                                                                                                                                                                                                                                                                                                                                                                                   |
|                               | 1 mg/kg SC, repeat in 7 days <a href="#">705</a>                                                              | Falcons/ <i>Serratospiculum</i>                                                                                                                                                                                                                                                                                                                                                           |
|                               | 2 mg/kg IM once <a href="#">791</a>                                                                           | Falcons/ <i>Capillaria</i> ; no adverse effects observed this dose                                                                                                                                                                                                                                                                                                                        |
|                               | 0.8-1 mg/L drinking water <a href="#">198</a>                                                                 | Canaries                                                                                                                                                                                                                                                                                                                                                                                  |



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|                                        | 1 drop (0.05 mL) to skin q7d × 3 treatments <sup><a href="#">43</a></sup>           | Pigeons, passerines/ <i>Knemidokopte</i> <i>Dermanyssus</i>                                                                                                                                                                                                                                                                                                                                                                        |
| Lasalocid (Avatec, Alparma)            | 67-125 mg/kg feed continuously <sup><a href="#">102,757,787</a></sup>               | Game birds, chickens/coccidia                                                                                                                                                                                                                                                                                                                                                                                                      |
| Levamisole (Tramisol, Schering-Plough) |                                                                                     | Many species/nematodes immunostimulant; low therapeutic index (toxic reactions, deaths reported do not use in debilitated birds; <sup><a href="#">43,506</a></sup> IM administration may cause severe toxicity; limb paralysis, vomiting, dysp reported in a parakeet; do use in white-faced ibis <sup><a href="#">672</a></sup> in lories; withhold food before treatment to prevent regurgitation <sup><a href="#">506</a></sup> |
|                                        | 2-5 mg/kg SC, IM, repeat in 10-14 days × 3 treatments <sup><a href="#">43</a></sup> | Psittacines/immunostimu                                                                                                                                                                                                                                                                                                                                                                                                            |
|                                        | 7.5 mg/kg PO, SC <sup><a href="#">102</a></sup>                                     | Ostriches                                                                                                                                                                                                                                                                                                                                                                                                                          |
|                                        | 7.5 mg/kg IM once; can repeat in 7 days <sup><a href="#">43</a></sup>               | Pigeons                                                                                                                                                                                                                                                                                                                                                                                                                            |
|                                        | 10-20 mg/kg PO, SC q24h × 2 days <sup><a href="#">149,363</a></sup>                 | Raptors                                                                                                                                                                                                                                                                                                                                                                                                                            |
|                                        | 10-20 mg/kg SC once <sup><a href="#">43,506</a></sup>                               | Most species                                                                                                                                                                                                                                                                                                                                                                                                                       |
|                                        | 15-20 mg/bird PO once, repeat in 10 days <sup><a href="#">126</a></sup>             | Pigeons                                                                                                                                                                                                                                                                                                                                                                                                                            |
|                                        | 20 mg/kg PO once <sup><a href="#">43,506</a></sup>                                  | Psittacines, pigeons, rapt                                                                                                                                                                                                                                                                                                                                                                                                         |
|                                        | 20-25 mg/kg SC <sup><a href="#">757</a></sup>                                       | Game birds                                                                                                                                                                                                                                                                                                                                                                                                                         |
|                                        | 20-50 mg/kg PO, SC once <sup><a href="#">43</a></sup>                               | Waterfowl                                                                                                                                                                                                                                                                                                                                                                                                                          |
|                                        | 30 mg/kg PO q10d <sup><a href="#">810</a></sup>                                     | Ratites                                                                                                                                                                                                                                                                                                                                                                                                                            |
|                                        | 40 mg/kg PO once <sup><a href="#">43,216,324,506</a></sup>                          | Psittacines, pigeons, chickens, raptors/ <i>Capilla</i> significantly higher bioavailability, volume of distribution and total body clearance in laying hens <sup><a href="#">2</a></sup>                                                                                                                                                                                                                                          |
|                                        | 100-200 mg/L drinking water × 3 days <sup><a href="#">126,147</a></sup>             | Psittacines, passerines, raptors                                                                                                                                                                                                                                                                                                                                                                                                   |

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|                                                                    | 264-396 mg/L drinking water × 1-3 days <sup><a href="#">324,506</a></sup>                              | Most species, including pigeons                                                                                             |
|                                                                    | 265-525 mg/L drinking water × 1 day, repeat in 7-14 days <sup><a href="#">757,849</a></sup>            | Game birds, poultry                                                                                                         |
|                                                                    | 375 mg/L drinking water as sole water source for 24 hr, repeat in 7 days <sup><a href="#">43</a></sup> | Pigeons                                                                                                                     |
| Maduramicin ammonium (Cygro, Alparma)                              | 5-6 mg/kg feed <sup><a href="#">511,787</a></sup>                                                      | Chickens, turkeys/coccid not available in the United States                                                                 |
| Malathion (Prozap Malathion 57EC, Loveland)                        | Dilute to 0.93%; paint or spray perches and premises <sup><a href="#">43</a></sup>                     | Raptors/organophosphate premise treatment; <i>Dermanyssus</i>                                                               |
| Mebendazole (Telmin Suspension, Telmintic Powder, Schering-Plough) | 5-6 mg/kg PO q24h × 3-5 days, repeat in 21 days <sup><a href="#">387</a></sup>                         | Pigeons                                                                                                                     |
|                                                                    | 5-7 mg/kg PO <sup><a href="#">810</a></sup>                                                            | Ostriches                                                                                                                   |
|                                                                    | 5-15 mg/kg PO q24h × 2 days <sup><a href="#">43,534</a></sup>                                          | Waterfowl/nematodes                                                                                                         |
|                                                                    | 10 mg/kg PO q12h × 5 days <sup><a href="#">506</a></sup>                                               | Canaries/avoid use during breeding season                                                                                   |
|                                                                    | 20 mg/kg PO q24h × 10-14 days <sup><a href="#">43,149</a></sup>                                        | Raptors/filarids                                                                                                            |
|                                                                    | 25 mg/kg PO q12h × 5 days <sup><a href="#">159,672</a></sup>                                           | Psittacines, ramphastids (toucans)/nematodes; may not be effective for proventricular and ventricular parasites             |
|                                                                    | 25 mg/kg PO q12h × 5 days, repeat q30d <sup><a href="#">363</a></sup>                                  | Raptors/intestinal nematodiasis                                                                                             |
|                                                                    | 50 mg/kg PO, repeat in 10-14 days <sup><a href="#">363</a></sup>                                       | Raptors/intestinal nematodiasis                                                                                             |
|                                                                    | 10-21 mg/L drinking water × 3-5 days <sup><a href="#">387</a></sup>                                    | Pigeons                                                                                                                     |
|                                                                    | 1.2 mg/kg feed × 14 days <sup><a href="#">63</a></sup>                                                 | Waterfowl/nematodes                                                                                                         |
| Mefloquine HCl (Lariam, Hoffman-LaRoche)                           | —                                                                                                      | Antimalarial; active against erythrocytic and tissue schizonts of some <i>Plasmodium</i> <sup><a href="#">665,792</a></sup> |
|                                                                    | 30 mg/kg PO q12h × 1 day, then q24h × 1-2 days <sup><a href="#">399,792,850</a></sup>                  | Raptors                                                                                                                     |
|                                                                    | 30 mg/kg PO q12h × 1 day, then q24h × 2 days, then q7d × 6 mo <sup><a href="#">399</a></sup>           | Raptors/long term administration                                                                                            |
|                                                                    | 30 mg/kg PO once weekly <sup><a href="#">660</a></sup>                                                 | Raptors/ <i>Plasmodium</i> rout prevention during insect                                                                    |

|                                                            |                                                                                                     |                                                                                                                                                                                      |
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|                                                            |                                                                                                     | season                                                                                                                                                                               |
|                                                            | 50 mg/kg q24h <sup>551</sup>                                                                        | Raptors/ <i>Haemoproteus</i> ; u<br>in conjunction with<br>chloroquine at doses up to<br>mg/kg                                                                                       |
|                                                            | 50 mg/kg PO q24h × 7 days <sup>126</sup>                                                            | Raptors/ <i>Plasmodium</i>                                                                                                                                                           |
| Melarsomine dihydrochloride<br>(Immiticide, Merial)        | —                                                                                                   | Organic arsenical                                                                                                                                                                    |
|                                                            | 0.25 mg/kg IM q24h × 4 days <sup>126</sup>                                                          | Raptors/ <i>Leucocytozoon</i>                                                                                                                                                        |
| Melarsomine dihydrochloride<br>(M)/ivermectin (I) (Merial) | (M) 0.25 mg/kg IM q 24h × 2 days<br>followed 10 days later with (I) 1 mg/kg<br>IM <sup>43,789</sup> | Falcons/ <i>Serratospiculum</i> ;<br>reduced clinical signs and<br>eliminated shedding of<br>embryonated eggs <sup>789</sup>                                                         |
| Metronidazole                                              | —                                                                                                   | Most species/antiprotozo<br>including alimentary trac<br>protozoa (especially<br>flagellates such as <i>Giardi</i><br><i>Histomonas</i> , <i>Spironucleu</i><br><i>Trichomonas</i> ) |
|                                                            | 10-20 mg/kg IM q12-24h × 2<br>days <sup>359,506</sup>                                               | Pigeons, psittacines                                                                                                                                                                 |
|                                                            | 10-30 mg/kg PO, IM q12h × 10<br>days <sup>43,812</sup>                                              | Psittacines                                                                                                                                                                          |
|                                                            | 20-25 mg/kg PO q12h <sup>810</sup>                                                                  | Ratites                                                                                                                                                                              |
|                                                            | 25 mg/kg PO q12h × 2-10 days <sup>402</sup>                                                         | Psittacine neonates                                                                                                                                                                  |
|                                                            | 25 mg/kg PO q12h × 10 days <sup>119</sup>                                                           | Turkeys/ <i>Trichomonas</i>                                                                                                                                                          |
|                                                            | 25-50 mg/kg PO q12-24h × 5-10<br>days <sup>359</sup>                                                | Companion birds/treatme<br>control, or prevention of<br><i>Giardia</i> , <i>Trichomonas</i> , ar<br><i>Hexamita</i>                                                                  |
|                                                            | 25-50 mg/kg PO q12-24h <sup>324</sup>                                                               | Pigeons/use lower dose w<br>twice daily dosing                                                                                                                                       |
|                                                            | 30 mg/kg PO via gavage once <sup>230</sup>                                                          | Finches/ <i>Cochlosoma</i>                                                                                                                                                           |
|                                                            | 30 mg/kg PO q12h <sup>167</sup>                                                                     | Poultry/PK, PD                                                                                                                                                                       |
|                                                            | 30 mg/kg PO q12h × 5-10 days <sup>49,548,654</sup>                                                  | Raptors, gouldian finches<br>psittacines/ <i>Trichomonas</i>                                                                                                                         |
|                                                            | 30-50 mg/kg PO q24h × 3-5 days <sup>660</sup>                                                       | Raptors/ <i>Trichomonas</i>                                                                                                                                                          |
|                                                            | 40 mg/kg PO q24h <sup>645</sup>                                                                     | Rheas                                                                                                                                                                                |
|                                                            | 40 mg/kg PO q24h × 7 days <sup>644</sup>                                                            | Budgerigars/ <i>Trichomona</i>                                                                                                                                                       |
|                                                            | 40-50 mg/kg PO q24h × 5-7 days <sup>126</sup>                                                       | Pigeons                                                                                                                                                                              |
|                                                            | 50 mg/kg PO <sup>119</sup>                                                                          | Waterfowl/flagellates                                                                                                                                                                |

|                                          |                                                                 |                                                                                               |
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|                                          | 50 mg/kg PO q24h × 5-7 days <a href="#">43,149,261,363</a>      | Raptors/ <i>Trichomonas</i> , <i>Giardia</i>                                                  |
|                                          | 50 mg/kg PO q12h × 5 days <a href="#">126,693</a>               | Pigeons, passerines                                                                           |
|                                          | 100 mg/kg PO q24h × 3 days <a href="#">707</a>                  | Falcons/ <i>Trichomonas</i>                                                                   |
|                                          | 100-150 mg PO total dose divided over 5 days <a href="#">43</a> | Pigeons                                                                                       |
|                                          | 110 mg/kg PO q12h <a href="#">321</a>                           | Poultry/ <i>Histomonas</i>                                                                    |
|                                          | 40 mg/L drinking water <a href="#">230</a>                      | Finches/ <i>Cochlosoma</i>                                                                    |
|                                          | 100 mg/L drinking water <a href="#">198</a>                     | Canaries                                                                                      |
|                                          | 200 mg/L drinking water × 7 days <a href="#">126</a>            | Passerines                                                                                    |
|                                          | 370 mg/L drinking water <a href="#">773</a>                     | Passerines/protozoal sinusitis                                                                |
|                                          | 400 mg/L drinking water × 5-15 days <a href="#">757,773</a>     | Game birds, passerines/protozoal sinusitis                                                    |
|                                          | 1057 mg/L drinking water <a href="#">324</a>                    | Pigeons                                                                                       |
|                                          | 1250 mg/L drinking water × 7-10 days <a href="#">534</a>        | Ratites                                                                                       |
|                                          | 100 mg/kg soft feed <a href="#">198</a>                         | Canaries                                                                                      |
|                                          | 200-400 mg/kg feed <a href="#">362</a>                          | Chickens/highly effective against <i>Histomonas</i> but reduced weight gains at higher dosage |
| Milbemycin oxime (Interceptor, Novartis) | 2 mg/kg PO, repeat in 28 days <a href="#">340</a>               | Galliformes/nematodes                                                                         |
| Monensin (Coban 45, Elanco)              | —                                                               | Ionophore antibiotic anticoccidial feed additive                                              |
|                                          | 53-94 mg/kg feed × 10 wk <a href="#">123,757</a>                | Turkeys                                                                                       |
|                                          | 73 mg/kg feed × 10 wk <a href="#">119</a>                       | Quail                                                                                         |
|                                          | 94 mg/kg feed <a href="#">114,757</a>                           | Quail, cranes/coccidia (including disseminated visceral coccidiosis)                          |
|                                          | 94-108 mg/kg feed × 8 wk <a href="#">757</a>                    | Chickens                                                                                      |
|                                          | 99 mg/kg feed <a href="#">115</a>                               | Sandhill cranes/prevented experimentally induced disseminated visceral coccidiosis            |
|                                          | 99.2 mg/kg feed <a href="#">647</a>                             | Turkeys/23/33 <i>Eimeria</i> isolates resistant                                               |
|                                          |                                                                 |                                                                                               |

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| Moxidectin (ProHeart, Fort Dodge)    | —                                                           | Treatment of <i>Serratospiculum</i> , <i>Capilla acanthocephalans</i> , <i>Paraspiralatus sakeri</i> , and <i>Physaloptera alata</i> in falcons <sup>43</sup>                     |
|                                      | 0.2 mg/kg PO <sup>126,705</sup>                             | Raptors/nematodes                                                                                                                                                                 |
|                                      | 0.2 mg/kg IM once <sup>159</sup>                            | Ramphastids (toucans)/repeat if necessary                                                                                                                                         |
|                                      | 0.5 mg/kg PO <sup>43</sup>                                  | Raptors                                                                                                                                                                           |
|                                      | 0.5-1 mg/kg PO <sup>126</sup>                               | Raptors/ <i>Capillaria</i>                                                                                                                                                        |
|                                      | 1 mg/bird topically once, or can repeat q10d × 2 treatments | Budgerigars/ <i>Knemidokop</i> no adverse effects seen at this dose in this species <sup>a</sup>                                                                                  |
| Narasin (Monteban 45, Elanco)        | 20-80 mg/kg feed <sup>787</sup>                             | Chickens/prophylactic coccidiostat; toxic to turkeys                                                                                                                              |
| Nicarbazin (Nicarb 25%, Merck AgVet) | 20-125 mg/kg feed <sup>787</sup>                            | Chickens/prophylactic coccidiostat                                                                                                                                                |
| Niclosamide (Yomesan, Bayer)         | —                                                           | Cestodes, trematodes; rarely used since praziquantel is more efficacious; may be toxic for geese and some Anseriformes; not available in the United States                        |
|                                      | 50-100 mg/kg PO, repeat in 10-14 days <sup>413</sup>        | Ostriches                                                                                                                                                                         |
|                                      | 220 mg/kg PO, repeat in 10-14 days <sup>329</sup>           | Most species                                                                                                                                                                      |
|                                      | 250 mg/kg PO q14d prn <sup>110</sup>                        | Cranes                                                                                                                                                                            |
|                                      | 500 mg/kg PO q7d × 4 wk <sup>329</sup>                      | Finches                                                                                                                                                                           |
| Oxfendazole (Benzelmin, Syntex)      | 5 mg/kg PO once <sup>146</sup>                              | Ostriches/nematodes                                                                                                                                                               |
|                                      | 10-40 mg/kg PO once <sup>506,767</sup>                      | Most species, including finches/nematodes                                                                                                                                         |
|                                      | 15-25 mg/kg PO once <sup>159</sup>                          | Ramphastids (toucans)/repeat in 15 days prn                                                                                                                                       |
|                                      | 20 mg/kg PO once <sup>341</sup>                             | Raptors                                                                                                                                                                           |
| Paromomycin (Humatin, Caraco-        |                                                             | Highest efficacy of all drugs tested thus far against <i>Cryptosporidium</i> ; oocyst output decreased by 67-80% in chickens; <sup>756</sup> may result in secondary bacterial or |

|                                                                              |                                                                                 |                                                                                                                                                                             |
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| Pharma)                                                                      | —                                                                               | mycotic infections; use w caution if ulcerative bow lesions are suspected because renal toxicity ma occur; <sup>359</sup> ineffective agai <i>Histomonas</i> <sup>362</sup> |
|                                                                              | 100 mg/kg PO q12h × 7 days <sup>136,261</sup>                                   | Most species, including macaw chicks, falcons/m 250 mg capsule with 10 n water to facilitate dosing; poorly absorbed                                                        |
|                                                                              | 1000 mg/kg soft food or hulled millet <sup>49</sup>                             | Gouldian finches/ <i>Cryptosporidium</i> ; may predispose to fungal infections                                                                                              |
| Permethrin (Adams, Pfizer)                                                   | Dust plumage lightly <sup>43</sup>                                              | Pigeons/lice, fleas                                                                                                                                                         |
| Permethrin/piperonyl butoxide/methoprene (Avian Insect Liquidator, Vetafarm) | Apply to plumage; spray cages, aviaries, bird rooms, surroundings <sup>43</sup> | Most species/lice, mites, flies, mosquitoes, moths; available in the United St                                                                                              |
| Phenylarsonic acid (Merck European Laboratories)                             | 22-45 mg/kg <sup>119</sup>                                                      | Chickens, turkeys/ <i>Histomonas</i> prevention; not recommended or approve for game birds; not availa in the United States                                                 |
| Piperazine (Wazine, Fleming Laboratories)                                    | —                                                                               | Most species/ascarids, oxyurids; less efficacious than fenbendazole; seldom used in companion birds                                                                         |
|                                                                              | 35 mg/kg PO q24h × 2 days <sup>324</sup>                                        | Pigeons/ascarids                                                                                                                                                            |
|                                                                              | 45-200 mg/kg PO once <sup>671</sup>                                             | Waterfowl/ <i>Tetrameres</i> , <i>Capillaria</i>                                                                                                                            |
|                                                                              | 50-100 mg/kg PO once <sup>534,757</sup>                                         | Emus, ostriches, chickens                                                                                                                                                   |
|                                                                              | 100 mg/kg PO, repeat in 14 days <sup>397,506</sup>                              | Raptors                                                                                                                                                                     |
|                                                                              | 100-400 mg/bird PO <sup>757</sup>                                               | Turkeys                                                                                                                                                                     |
|                                                                              | 100-500 mg/kg PO once, repeat in 10-14 days <sup>757</sup>                      | Game birds                                                                                                                                                                  |
|                                                                              | 250 mg/kg PO once <sup>506</sup>                                                | Psittacines, pigeons                                                                                                                                                        |
|                                                                              | 79 mg/L drinking water × 2 days <sup>324</sup>                                  | Pigeons/ascarids                                                                                                                                                            |
|                                                                              | 1000 mg/L drinking water × 3 days <sup>63,506</sup>                             | Raptors, pigeons                                                                                                                                                            |
|                                                                              |                                                                                 |                                                                                                                                                                             |

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|                                                        | 1000 mg/L drinking water; repeat in 10-14 days <sup><a href="#">43</a></sup>          | Gallinaceous birds/not effective in psittacines, finches                                                                                  |
|                                                        | 1000-2000 mg/L drinking water × 1-2 days <sup><a href="#">102,126,757</a></sup>       | Game birds, pigeons                                                                                                                       |
|                                                        | 1600-2600 mg/L drinking water <sup><a href="#">119</a></sup>                          | Waterfowl/ <i>Tetrameres</i> , <i>Capillaria</i>                                                                                          |
|                                                        | 3700 mg/L drinking water × 12 hr, repeat in 14-21 days <sup><a href="#">126</a></sup> | Passerines                                                                                                                                |
| Piperonyl butoxide/pyrethrin (Ridmite Powder, Johnson) | Dust plumage, repeat in 10 days <sup><a href="#">43</a></sup>                         | Psittacines                                                                                                                               |
|                                                        | Dust plumage, repeat in 21 days <sup><a href="#">43</a></sup>                         | Raptors                                                                                                                                   |
| Ponazuril (Marquis 5% paste; Bayer)                    | —                                                                                     | Triazine coccidiocidal dr metabolite of toltrazuril                                                                                       |
|                                                        | 20 mg/kg q24h × 7 days <sup><a href="#">829</a></sup>                                 | Falcons/respiratory <i>Cryptosporidium baileyi</i>                                                                                        |
| Praziquantel (Droncit, Bayer)                          | —                                                                                     | Most species/cestodes, trematodes; toxic in finch and associated with depression, death in some species <sup><a href="#">43,672</a></sup> |
|                                                        | 1 mg/kg PO <sup><a href="#">43</a></sup>                                              | Bustards/well tolerated                                                                                                                   |
|                                                        | 5-10 mg/kg PO, repeat after 2-4 wk <sup><a href="#">43,147,149</a></sup>              | Psittacines, passerines, raptors                                                                                                          |
|                                                        | 5-10 mg/kg PO, SC q24h × 14 days <sup><a href="#">43,63,119,363</a></sup>             | Raptors, waterfowl/trematodes                                                                                                             |
|                                                        | 6 mg/kg PO, IM, repeat in 10-14 days <sup><a href="#">111</a></sup>                   | Cranes                                                                                                                                    |
|                                                        | 7.5 mg/kg PO <sup><a href="#">70,534</a></sup>                                        | Ostriches                                                                                                                                 |
|                                                        | 7.5 mg/kg SC, IM repeat in 2-4 wk <sup><a href="#">126,147</a></sup>                  | Most species, except finc                                                                                                                 |
|                                                        | 8.5 mg/kg IM <sup><a href="#">16</a></sup>                                            | Chickens                                                                                                                                  |
|                                                        | 9 mg/kg IM, repeat in 10 days <sup><a href="#">43,64</a></sup>                        | Psittacines/cestodes                                                                                                                      |
|                                                        | 10 mg/kg PO, IM, SC once; repeat in 7 days <sup><a href="#">261</a></sup>             | Raptors/cestodes, tremat                                                                                                                  |
|                                                        | 10 mg/kg SC, IM q24h × 3 days, then PO × 11 days <sup><a href="#">363,812</a></sup>   | Psittacines, raptors/trematodes                                                                                                           |
|                                                        | 10 mg/kg PO <sup><a href="#">16</a></sup>                                             | Chickens                                                                                                                                  |
|                                                        | 10 mg/kg IM q24h × 3 days, then PO q24h × 11 days <sup><a href="#">286</a></sup>      | Toucans/trematodes                                                                                                                        |
|                                                        |                                                                                       | Waterfowl,                                                                                                                                |



|            |                                                                                                             |                                                                                                                                                                                                                                     |
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|            | 10 mg/kg PO, SC, IM q24h × 14 days <sup><a href="#">43,159</a></sup>                                        | toucans/trematodes; in toucans, follow with 6 mg PO q24h × 14 days <sup><a href="#">672</a></sup>                                                                                                                                   |
|            | 10-20 mg/kg PO, repeat in 10-14 days <sup><a href="#">43,70,126,324</a></sup>                               | Most species including pigeons, waterfowl                                                                                                                                                                                           |
|            | 10-20 mg/kg SC, IM, repeat in 10 days <sup><a href="#">63</a></sup>                                         | Waterfowl/cestodes                                                                                                                                                                                                                  |
|            | 11 mg/kg SC once <sup><a href="#">16</a></sup>                                                              | Chickens                                                                                                                                                                                                                            |
|            | 25 mg/kg PO, IM, repeat in 10-14 days <sup><a href="#">570</a></sup>                                        | Bali mynahs/cestodes                                                                                                                                                                                                                |
|            | 30-50 mg/kg PO, SC, IM, repeat in 14 days <sup><a href="#">363,397</a></sup>                                | Raptors/cestodes                                                                                                                                                                                                                    |
|            | 12 mg crushed and baked into 9" × 9" × 2" cake <sup><a href="#">506</a></sup>                               | Finches/withhold regular feed                                                                                                                                                                                                       |
| Primaquine | —                                                                                                           | Pigeons, raptors, game birds, penguins/hematozoa (i.e. <i>Plasmodium</i> , <i>Haemoproteus</i> , <i>Leucocytozoon</i> ); use in conjunction with chloroquine; dosage based on amount of active base rather than total tablet weight |
|            | 0.03 mg/kg PO q24h × 3 days <sup><a href="#">134,671,757</a></sup>                                          | Game birds, penguins                                                                                                                                                                                                                |
|            | 0.3 mg/kg PO (at 24 hr following the initial chloroquine dose) q24h × 7 days <sup><a href="#">113</a></sup> | Raptors/use with chloroquine (10 mg/kg at 0 hr, then 5 mg/kg at 6, 24, and 48 hr)                                                                                                                                                   |
|            | 0.3 mg/kg PO q24h × 10 days <sup><a href="#">266</a></sup>                                                  | Penguins/ <i>Plasmodium</i> ; use with chloroquine (10 mg/kg at 0 hr, then 5 mg/kg at 6 and 24 hr)                                                                                                                                  |
|            | 0.75 mg/kg PO q24h × 5 days <sup><a href="#">790</a></sup>                                                  | Falcons/ <i>Haemoproteus tinnunculi</i>                                                                                                                                                                                             |
|            | 0.75-1 mg/kg PO once <sup><a href="#">661,747</a></sup>                                                     | Most species, including raptors/ <i>Plasmodium</i> ; use with chloroquine (25 mg/kg at 0 hr, then 15 mg/kg at 24, and 48 hr); palliative therapy                                                                                    |
|            | 1 mg/kg PO q7d <sup><a href="#">661</a></sup>                                                               | Most species/use with chloroquine (10 mg/kg q7d) as a preventative regimen for birds recovering from                                                                                                                                |



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|                                    |                                                                                         | <i>Plasmodium</i> infection                                                                                                                 |
|                                    | 1 mg/kg PO q24h × 2 days, repeat q7d × 3-5 treatments to prevent relapse <sup>661</sup> | Raptors/ <i>Plasmodium</i> ; use with chloroquine (20 mg/IV initially, followed by 10 mg/kg PO at 6, 18, and 24 hr)                         |
|                                    | 1 mg/kg PO q24h × 45 days <sup>843</sup>                                                | Psittacines (keas)/ <i>Sarcocystis</i> ; use in combination with amprolium, enrofloxacin, pyrimethamine                                     |
|                                    | 1.25 mg/kg PO q24h <sup>266</sup>                                                       | Penguins/prophylactic therapy against <i>Plasmodi</i>                                                                                       |
| Pyrantel pamoate                   | —                                                                                       | Intestinal nematodes                                                                                                                        |
|                                    | 4.5 mg/kg PO, repeat in 10-14 days <sup>43,853</sup>                                    | Psittacines, including cockatoo chicks <sup>853</sup>                                                                                       |
|                                    | 5-7 mg/kg PO <sup>810</sup>                                                             | Ostriches                                                                                                                                   |
|                                    | 7 mg/kg PO, repeat in 14 days <sup>141</sup>                                            | Most species                                                                                                                                |
|                                    | 7-20 mg/kg PO, repeat in 14 days <sup>363</sup>                                         | Raptors                                                                                                                                     |
|                                    | 20 mg/kg PO once <sup>43,149</sup>                                                      | Raptors                                                                                                                                     |
|                                    | 20-25 mg/kg PO <sup>324</sup>                                                           | Pigeons                                                                                                                                     |
|                                    | 70 mg/kg PO once <sup>159</sup>                                                         | Ramphastids (toucans)/repeat if necessary                                                                                                   |
|                                    | 148 mg/L drinking water <sup>692</sup>                                                  | Psittacines, pigeons/medication float                                                                                                       |
| Pyrethrins (0.15%) (Adams, Pfizer) | Dust plumage lightly to moderately prn <sup>63,692</sup>                                | Most species, including psittacines, pigeons/ectoparasites                                                                                  |
| Pyrimethamine (Fansidar, Roche)    | —                                                                                       | <i>Toxoplasma</i> , <i>Atoxoplasma</i> , <i>Sarcocystis</i> ; may be effective for <i>Leucocytozo</i> supplement with folic or folinic acid |
|                                    | 0.25-0.5 mg/kg PO q12h × 30 days <sup>43,149</sup>                                      | Raptors, waterfowl/ <i>Sarcocystis</i> , <i>Toxoplasma</i>                                                                                  |
|                                    | 0.5 mg/kg PO q12h × 14-28 days <sup>126,141</sup>                                       | Most species/use for 28 d for <i>Leucocytozoon</i> in raptors <sup>126</sup>                                                                |
|                                    | 0.5 mg/kg PO q12h × 30 days <sup>63</sup>                                               | Waterfowl/ <i>Sarcocystis</i>                                                                                                               |
|                                    |                                                                                         | Psittacines                                                                                                                                 |

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|                                          | 0.5 mg/kg PO q12h × 45 days <sup><a href="#">843</a></sup>                                       | (keas)/ <i>Sarcocystis</i> ; use in combination with amprol and primaquine                                                                               |
|                                          | 0.5-1 mg/kg PO q12h × 2-4 days, then 0.25 mg/kg PO q12h × 30 days <sup><a href="#">359</a></sup> | Companion birds/ <i>Sarcocystis</i> ; use in combination with trimethoprim-sulfa 5 mg/IM q12h or 30-100 mg/kg PO q12h × 7 days                           |
|                                          | 0.5-1 mg/kg PO q12h × 30 days <sup><a href="#">592</a></sup>                                     | Eclectus, Amazon parrots/use with trimethoprim-sulfadiazin (30 mg/kg)                                                                                    |
|                                          | 1 mg/kg feed <sup><a href="#">757</a></sup>                                                      | Game birds                                                                                                                                               |
|                                          | 100 mg/kg feed <sup><a href="#">141</a></sup>                                                    | Most species                                                                                                                                             |
| Quinacrine HCl (Atabrine, Sanofi)        | —                                                                                                | Most species/ <i>Atoxoplasma Plasmodium</i> ; chloroquine and primaquine are preferred; overdose may cause hepatotoxicity <sup><a href="#">506</a></sup> |
|                                          | 5-10 mg/kg PO q24h × 7-10 days <sup><a href="#">392,506</a></sup>                                | Most species/use higher doses for <i>Lankesterella</i> , <i>Plasmodium</i>                                                                               |
|                                          | 7.5 mg/kg PO q24h × 10 days <sup><a href="#">506</a></sup>                                       | Most species/ <i>Atoxoplasma</i>                                                                                                                         |
|                                          | 26-79 mg/L drinking water × 10-21 days <sup><a href="#">324</a></sup>                            | Pigeons                                                                                                                                                  |
| Rafoxanide (Flukex, Univet; Ranide, MSD) | 10 mg/kg PO <sup><a href="#">876</a></sup>                                                       | Raptors/trematodes, cestodes; not available in United States                                                                                             |
| Resorantel (Terenol-S, Intervet)         | 130 mg/kg PO <sup><a href="#">413,511</a></sup>                                                  | Ostriches/cestodes; administer with or without fenbendazole                                                                                              |
| Robenidine HCl (Bio-Cox, Alpharma)       | 4-6 mg/kg PO q24h × 6 days <sup><a href="#">511</a></sup>                                        | Pigeons/prophylaxis for coccidiosis                                                                                                                      |
|                                          | 6-10 mg/kg PO q24h × 6-10 days <sup><a href="#">511</a></sup>                                    | All species                                                                                                                                              |
|                                          | 4 mg/L drinking water × 7 days <sup><a href="#">506</a></sup>                                    | Songbirds                                                                                                                                                |
|                                          | 10-20 mg/L drinking water × 7 days <sup><a href="#">506,511</a></sup>                            | Cockatiels, pigeons                                                                                                                                      |
|                                          | 100 mg/L drinking water × 3-5 days <sup><a href="#">506,511</a></sup>                            | Pigeons                                                                                                                                                  |
|                                          | 33 mg/kg feed <sup><a href="#">511,787</a></sup>                                                 | Chickens                                                                                                                                                 |
|                                          | 2.5 mg/kg PO × 6 days <sup><a href="#">324</a></sup>                                             | Pigeons                                                                                                                                                  |

|                                     |                                                                          |                                                                                                                                                                                                                                        |
|-------------------------------------|--------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Ronidazole (Ronivet-S, Vetafarm)    | 6-10 mg/kg PO q24h × 6-10 days <sup><a href="#">506</a></sup>            | Most species                                                                                                                                                                                                                           |
|                                     | 10-20 mg/kg PO q24h × 7 days <sup><a href="#">126</a></sup>              | Pigeons                                                                                                                                                                                                                                |
|                                     | 12.5 mg/kg PO × 6 days <sup><a href="#">43</a></sup>                     | Pigeons                                                                                                                                                                                                                                |
|                                     | 50-400 mg/L drinking water × 5 days <sup><a href="#">126</a></sup>       | Passerines                                                                                                                                                                                                                             |
|                                     | 60 mg/L drinking water <sup><a href="#">230</a></sup>                    | Finches/ <i>Cochlosoma</i>                                                                                                                                                                                                             |
|                                     | 100 mg/L drinking water × 5-7 days <sup><a href="#">702</a></sup>        | Pigeons/flock preventative dose; treatment of choice <i>Trichomonas</i> <sup><a href="#">308</a></sup>                                                                                                                                 |
|                                     | 100-200 mg/L drinking water × 7 days <sup><a href="#">506</a></sup>      | Cockatiels, pigeons/high dosage required for resistant strains in pigeons                                                                                                                                                              |
|                                     | 100-600 mg/L drinking water × 3-5 days <sup><a href="#">324</a></sup>    | Pigeons                                                                                                                                                                                                                                |
|                                     | 400 mg/L drinking water × 5-7 days <sup><a href="#">43,198,511</a></sup> | Canaries, pigeons/flock treatment; <i>Trichomonas</i> ; preventive dose <sup><a href="#">43</a></sup>                                                                                                                                  |
|                                     | 600 mg/L drinking water × 5-7 days <sup><a href="#">43</a></sup>         | Pigeons/ <i>Trichomonas</i> ; flock treatment                                                                                                                                                                                          |
|                                     | 1000 mg/L drinking water q24h <sup><a href="#">126</a></sup>             | Pigeons/equivalent to 12.5 mg/kg/day                                                                                                                                                                                                   |
|                                     | 400 mg/kg soft feed <sup><a href="#">198,511</a></sup>                   | Canaries                                                                                                                                                                                                                               |
| Rotenone (Ear Miticide, Vedco)      | Topical <sup><a href="#">876</a></sup>                                   | Most species/ <i>Knemidokoptes</i>                                                                                                                                                                                                     |
| Selamectin (Revolution, Pfizer)     | —                                                                        | No adverse effects, including neurological signs, were seen in healthy zebra finches with doses up to 92 mg/kg <sup><a href="#">69</a></sup>                                                                                           |
|                                     | 23 mg/kg topically, repeat in 3-4 weeks <sup><a href="#">68</a></sup>    | Budgerigars/ <i>Knemidokoptes</i> improvement in 13/14 birds at 4 wk, with no neurological signs identified but monitoring for weight loss                                                                                             |
| Sulfachlorpyrazine (ESB3, Novartis) | —                                                                        | Coccidiostat; affects the intestinal stages of <i>Atoxoplasma</i> ; <sup><a href="#">198</a></sup> not available in the United States, but can be obtained through the Bali mynah Species Survival Plan <sup><a href="#">572</a></sup> |
|                                     |                                                                          | Bali mynahs/ <i>Atoxoplasma</i> significantly reduced or                                                                                                                                                                               |

|                                                        |                                                                                                                                           |                                                                                                                                                                       |
|--------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                                                        | 1 g of 30% powder/L drinking water × 5 days, off 3 days, on 5 days, then repeat cycle 4x; administer treatment 3x annually <sup>572</sup> | totally cleared oocyst shedding for extended time; it is uncertain if the drug is safe to use when parents are feeding chicks; supplement with vitamin B <sub>6</sub> |
| Sulfachlorpyridazine (Vetisulid, Boehringer-Ingelheim) | —                                                                                                                                         | Coccidiostat; used as replacement for sulfachlorpyrazine in the United States                                                                                         |
|                                                        | 150-300 mg/L drinking water; <sup>198</sup> 5 days/wk × 2-3 weeks <sup>173</sup>                                                          | Passerines, including canaries/may need to treat for months for systemic coccidiosis                                                                                  |
|                                                        | 300 mg/L drinking water × 5 days, off 3 days, on 5 days, then repeat cycle 4x; administer treatment 3x annually <sup>572</sup>            | Passerines, including Bal mynahs/ <i>Atoxoplasma</i>                                                                                                                  |
|                                                        | 300 mg/L drinking water × 7-10 days <sup>324</sup>                                                                                        | Pigeons                                                                                                                                                               |
|                                                        | 300-1000 mg/L drinking water × 3 days, off 2 days, then repeat course <sup>126</sup>                                                      | Pigeons                                                                                                                                                               |
|                                                        | 400 mg/L drinking water × 30 days <sup>692</sup>                                                                                          | Cockatiels, budgerigars/mixture is stable for up to 5 days if refrigerated; change daily mix well                                                                     |
|                                                        | 400-500 mg/L drinking water × 5 days, off 2 days, on 5 days <sup>506</sup>                                                                | Most species                                                                                                                                                          |
| Sulfadimethoxine (12.5%) (Albon, Pfizer)               | 20 mg/kg PO q12h <sup>96</sup>                                                                                                            | Most species/treatment a prophylaxis of coccidia                                                                                                                      |
|                                                        | 25 mg/kg PO q12h × 5 days <sup>324</sup>                                                                                                  | Most species                                                                                                                                                          |
|                                                        | 25-50 mg/kg PO q24h × 3 days <sup>397</sup>                                                                                               | Raptors                                                                                                                                                               |
|                                                        | 25-50 mg/kg PO q24h × 3 days, off 2 days, then q24h × 3 days <sup>363</sup>                                                               | Raptors                                                                                                                                                               |
|                                                        | 25-55 mg/kg PO q 24h × 3-7 days <sup>658</sup>                                                                                            | Raptors/ <i>Eimeria</i> , <i>Sarcocystis</i>                                                                                                                          |
|                                                        | 50 mg/kg PO once, then 25 mg/kg PO q24h × 7-10 days <sup>363</sup>                                                                        | Raptors                                                                                                                                                               |
|                                                        | 50 mg/kg PO q24h × 5 days, off 3 days, on 5 days <sup>812</sup>                                                                           | Psittacines                                                                                                                                                           |
|                                                        | 250 mg/kg IM q24h × 3 days, off 2 days, on 3 days <sup>92</sup>                                                                           | Pigeons/PK, PD; close to toxic level                                                                                                                                  |
|                                                        |                                                                                                                                           |                                                                                                                                                                       |

|                                                              |                                                                                                                                 |                                                                             |
|--------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------|
|                                                              | 250 mg/L drinking water × 5 days <sup>757</sup><br>330-400 mg/L drinking water × 1 day<br>then 200 mg/L × 4 days <sup>324</sup> | Turkeys<br>Pigeons/supplement with<br>vitamin B for 5 days                  |
|                                                              | 500 mg/L drinking water × 6 days <sup>757</sup>                                                                                 | Chickens                                                                    |
| Sulfadimethoxine/ormetoprim<br>(Rofenaid, Hoffmann-La Roche) | 10 mg/kg feed <sup>757</sup>                                                                                                    | Game birds/coccidia,<br><i>Leucocytozoon</i> , <i>Sarcocys</i>              |
|                                                              | 320-525 mg/L drinking water <sup>321</sup>                                                                                      | Poultry                                                                     |
| Sulfadimidine sodium (33.3%)<br>(Neotrizine, Lilly)          | 40-50 mg/kg PO q24h × 7 days or 3<br>days on, 2 days off <sup>126</sup>                                                         | Pigeons                                                                     |
|                                                              | 50-150 mg/kg PO, IM q24h × 5-7<br>days <sup>242</sup>                                                                           | Raptors/coccidia; lack of<br>efficacy reported in<br>merlins <sup>262</sup> |
|                                                              | 3330-6660 mg/L drinking water × 3-5<br>days on, 2 days off repeated twice <sup>43</sup>                                         | Pigeons/coccidia; may be<br>effective against <i>Toxopla</i>                |
| Sulfamethazine (Sulmet,<br>Boehringer-Ingelheim)             | —                                                                                                                               | See sulfonamides;<br>coccidiostat; consider<br>vitamin B supplementati      |
|                                                              | 50-65 mg/pigeon PO × 3 days, off 2-3<br>days, repeat × 2-3 days <sup>434</sup>                                                  | Pigeons                                                                     |
|                                                              | 50-65 mg/pigeon PO × 5 days <sup>324,434</sup>                                                                                  | Pigeons/supplement vitar<br>B for 5 days <sup>324</sup>                     |
|                                                              | 75 mg/kg PO q24h × 3 days, off 2 days,<br>on 3 days <sup>506</sup>                                                              | Parakeets                                                                   |
|                                                              | 125-185 mg/kg PO q24h × 2 days, then<br>64-94 mg/kg × 4 days <sup>388</sup>                                                     | Chickens                                                                    |
|                                                              | 125 mg/L drinking water × 3 days, off 2<br>days, on 3 days <sup>506</sup>                                                       | Most species                                                                |
|                                                              | 400 mg/L drinking water once, then<br>200-270 mg/L × 4 days <sup>324</sup>                                                      | Pigeons                                                                     |
| Sulfaquinoxaline (Sulquin 6-50,<br>Solvay)                   | —                                                                                                                               | Sulfonamide used for<br>prevention and treatment<br>coccidiosis             |
|                                                              | 100 mg/kg PO q24h × 3 days, off 2<br>days, on 3 days <sup>506</sup>                                                             | Lories, pigeons                                                             |
|                                                              | 250 mg/L drinking water × 6 days, off 2<br>days, on 6 days <sup>692</sup>                                                       | Turkeys                                                                     |
|                                                              | 400 mg/L (1.4 mL/L) drinking water ×<br>6 days, off 2 days, on 6 days <sup>692</sup>                                            | Chickens                                                                    |
|                                                              | 500 mg/L (1.8 mL/L) drinking water ×<br>6 days, off 2 days, on 6 days <sup>693</sup>                                            | Pigeons                                                                     |

|                              |                                                                                          |                                                                                                                                                                                                                                                                                                                                             |
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|                              | 225 mg/kg feed continuously <sup>757</sup><br>450 mg/kg feed continuously <sup>757</sup> | Turkeys<br>Chickens                                                                                                                                                                                                                                                                                                                         |
| Sulfonamides                 | —                                                                                        | Competitively inhibit para-aminobenzoic acid, required by schizonts for folic acid synthesis; <sup>434</sup> contraindicated with dehydration, liver disease, or bone marrow suppression; gastrointestinal upset, regurgitation are common, especially in macaws; use for longer than 2 wk may require vitamin (folic acid) supplementation |
| Thiabendazole                | —                                                                                        | Most species/nematodes, acanthocephalans; generally less efficacious than fenbendazole; may be toxic to cranes, ratites, diving ducks <sup>43</sup>                                                                                                                                                                                         |
|                              | 40-100 mg/kg PO q24h × 7 days <sup>506</sup>                                             | Most species                                                                                                                                                                                                                                                                                                                                |
|                              | 50 mg/kg PO, repeat in 14 days <sup>534</sup>                                            | Ostriches                                                                                                                                                                                                                                                                                                                                   |
|                              | 100 mg/kg PO once, repeat in 10-14 days <sup>747</sup>                                   | Raptors                                                                                                                                                                                                                                                                                                                                     |
|                              | 100 mg/kg PO q24h × 7-10 days <sup>387</sup>                                             | Most species/gapeworms<br>ascarids                                                                                                                                                                                                                                                                                                          |
|                              | 100-200 mg/kg PO q12h × 10 days <sup>149</sup>                                           | Raptors/nematodes; may interfere with egg laying                                                                                                                                                                                                                                                                                            |
|                              | 100-500 mg/kg PO once <sup>506</sup>                                                     | Most species                                                                                                                                                                                                                                                                                                                                |
|                              | 250-500 mg/kg PO, repeat in 10-14 days <sup>43,812</sup>                                 | Most species, including psittacines/ascarids                                                                                                                                                                                                                                                                                                |
|                              | 425 mg/kg feed × 14 days <sup>113,757</sup>                                              | Pheasants, cranes                                                                                                                                                                                                                                                                                                                           |
| Tinidazole (Fasigyn, Pfizer) | 50 mg/kg PO once <sup>506</sup>                                                          | Most species/ <i>Giardia</i> , <i>Trichomonas</i> , <i>Entamoeba</i>                                                                                                                                                                                                                                                                        |
|                              | 200-400 mg/kg feed <sup>362</sup>                                                        | Chickens/ <i>Histomonas</i> ; depressed weight gain on higher dosage                                                                                                                                                                                                                                                                        |
|                              |                                                                                          | Coccidiocidal; <sup>434</sup> efficacious for refractory coccidiosis has been successful in reducing mortality from <i>Attoxoplasma</i> in canaries                                                                                                                                                                                         |

|                             |                                                                     |                                                                                                                                                                                                                                                                                                                                   |
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| Toltrazuril (Baycox, Bayer) | —                                                                   | other passerines and may affect systemic stages of disease; <sup>572</sup> not very effective against <i>Atoxoplasma</i> when given in water; bitter taste; mixing with soft drink (i.e. cola) increases palatability; <sup>43</sup> 2.5% solution is very alkaline and should not be gavaged directly in the crop <sup>434</sup> |
|                             | 7 mg/kg PO q24h × 2-3 days <sup>358,397</sup>                       | Budgerigars, raptors                                                                                                                                                                                                                                                                                                              |
|                             | 10 mg/kg PO q24h × 2 days <sup>658</sup>                            | Raptors/preferred treatment for <i>Caryospora</i>                                                                                                                                                                                                                                                                                 |
|                             | 10 mg/kg PO q48h × 3 treatments <sup>43</sup>                       | Raptors/treatment of choice for coccidiosis in falcons                                                                                                                                                                                                                                                                            |
|                             | 12.5 mg/kg PO q24h × 14 days <sup>570</sup>                         | Bali mynahs/ <i>Atoxoplasma</i> dosage is based on a limited number of clinical cases                                                                                                                                                                                                                                             |
|                             | 15-25 mg/kg PO q24h × 2 days <sup>43</sup>                          | Raptors                                                                                                                                                                                                                                                                                                                           |
|                             | 20-35 mg/kg PO once <sup>830</sup>                                  | Pigeons/higher dose prevents shedding up to 4 wk; low dose is minimum dose required to suppress oocyst shedding                                                                                                                                                                                                                   |
|                             | 25 mg/kg PO q7d × 3 treatments <sup>126,261</sup>                   | Raptors/ <i>Caryospora</i> , coccidiosis                                                                                                                                                                                                                                                                                          |
|                             | 2 mg/L drinking water × 2 consecutive days/wk <sup>147</sup>        | Psittacines                                                                                                                                                                                                                                                                                                                       |
|                             | 5 mg/L drinking water × 2 days, repeat in 14-21 days <sup>471</sup> | Lories/10 mg/L administered during second course of treatment                                                                                                                                                                                                                                                                     |
|                             | 12.5 mg/L drinking water × 2 days <sup>43</sup>                     | Waterfowl                                                                                                                                                                                                                                                                                                                         |
|                             | 20 mg/kg in drinking water × 2 days <sup>434</sup>                  | Pigeons                                                                                                                                                                                                                                                                                                                           |
|                             | 25 mg/L drinking water × 2 days <sup>213</sup>                      | Chickens/effective in preventing disease and reducing total oocysts, lesions, and mortality in infected birds with mixed <i>Eimeria</i> infections                                                                                                                                                                                |
|                             | 25 mg/L drinking water × 2 days, repeat in 5 days <sup>307</sup>    | Geese                                                                                                                                                                                                                                                                                                                             |
|                             |                                                                     | Cockatiels, passerines                                                                                                                                                                                                                                                                                                            |



|                                                                                            |                                                                                     |                                                                                                                                           |
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|                                                                                            | 25 mg/L drinking water × 2 days, repeat in 14-21 days <sup>471</sup>                | (including goldfinches, manikins, siskins)/coccidia                                                                                       |
|                                                                                            | 75 mg/L drinking water × 2 days/wk × 4 wk <sup>173</sup>                            | Passerines                                                                                                                                |
|                                                                                            | 75 mg/L drinking water × 5 days <sup>325</sup>                                      | Pigeons                                                                                                                                   |
|                                                                                            | 125 mg/L drinking water × 5 days <sup>43</sup>                                      | Pigeons                                                                                                                                   |
| Trimethoprim/sulfachlorpyridazine (1:5 ratio; Cosumix Plus, Novartis)                      | —                                                                                   | See sulfonamides                                                                                                                          |
|                                                                                            | 400 mg/kg feed <sup>388,672</sup>                                                   | Geese                                                                                                                                     |
| Trimethoprim/sulfadiazine (Di-Trim, Boehringer-Ingelheim; Duphatrim 24% injection, Solvay) | —                                                                                   | See sulfonamides                                                                                                                          |
|                                                                                            | 5 mg/kg IM q12h <sup>359</sup>                                                      | Companion birds/ <i>Sarcocystis</i> ; use in conjunction with pyrimethamine (0.5-1 mg PO q12h × 2 days, then 0.1 mg/kg PO q12h × 30 days) |
|                                                                                            | 30 mg/kg PO q8-12h <sup>65,363</sup>                                                | Most species, including psittacines, raptors/ <i>Sarcocystis</i> (treat at least 6 wk); coccidia                                          |
|                                                                                            | 30-100 mg/kg PO q12h × 7 days <sup>359</sup>                                        | Companion birds/ <i>Sarcocystis</i> ; use in conjunction with pyrimethamine (0.5-1 mg PO q12h × 2 days, then 0.1 mg/kg PO q12h × 30 days) |
|                                                                                            | 60 mg/kg PO, SC q12h × 3 days, off 2 days, on 3 days <sup>43</sup>                  | Raptors, waterfowl/coccidia                                                                                                               |
|                                                                                            | 80 mg/mL drinking water (trimethoprim)/40 mg/mL water (sulfadiazine) <sup>852</sup> | Canaries/ <i>Toxoplasma gondii</i>                                                                                                        |
| Trimethoprim/sulfamethoxazole (Bactrim, Roche; Septra, Burroughs Welcome)                  | 25 mg/kg PO q24h <sup>672</sup>                                                     | Toucans, mynahs/coccidia                                                                                                                  |
|                                                                                            | 30 mg/kg PO q12-24h <sup>126</sup>                                                  | Passerines/antiprotozoal                                                                                                                  |
|                                                                                            | 320-525 mg/L drinking water <sup>321</sup>                                          | Poultry/coccidia                                                                                                                          |
|                                                                                            | 480 mg/L drinking water q24h <sup>126</sup>                                         | Pigeons/antiprotozoal                                                                                                                     |

<sup>a</sup> Toparlak M. Personal communication. 1999.



TABLE 5-5 Chemical Restraint/Anesthetic/Analgesic Agents Used in Birds.<sup>a,b</sup>

| Agent                                             | Dosage                                          | Species/Comments                                                                                                                                                                                                                                                                             |
|---------------------------------------------------|-------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Acepromazine                                      | —                                               | Phenothiazine tranquilizer; see etorphine and ketamine for combinations                                                                                                                                                                                                                      |
|                                                   | 0.1-0.2 mg/kg IV <sup>384</sup>                 | Ratites/most commonly used in combination with other anesthetics; rarely used in other bird species                                                                                                                                                                                          |
|                                                   | 0.25-0.5 mg/kg IM <sup>384</sup>                |                                                                                                                                                                                                                                                                                              |
| Alphachloralose (Fisher Scientific)               | —                                               | Chloral derivative of glucose which depresses cortical centers of the brain; <sup>58</sup> induces hypothermia; <sup>70</sup> low therapeutic index in chickens suggests only marginally safe in domestic species or for field applications where dosage difficult to control <sup>472</sup> |
|                                                   | 30 mg/kg PO once <sup>58</sup>                  | Canada geese/immobilization of nuisance geese; prepare suspension in corn oil, inject into individual bread baits and hand-toss to target individuals; onset approximately 60 min, duration up to 24 hr                                                                                      |
|                                                   | 250-430 mg/cup of bait <sup>119,442</sup>       | Cranes, American crows, waterfowl (including Canada geese)/immobilization; 160-210 mg per 4.5 kg sandhill crane; cranes could generally be approached within 1-2 hr of feeding and releasable 8-22 hr later                                                                                  |
| Alphaxalone/alphadalone (Saffan, Schering-Plough) | —                                               | Steroid anesthetic with relatively low therapeutic index; not available in the United States; see ketamine for combination                                                                                                                                                                   |
|                                                   | 4-8 mg/kg IV <sup>43</sup>                      | Bustards, cranes, flamingos/short duration (8-10 min) surgical anesthesia                                                                                                                                                                                                                    |
|                                                   | 5-10 mg/kg IM, IV <sup>43,145,193,445,446</sup> | Psittacines, pigeons/transient apnea may occur                                                                                                                                                                                                                                               |
|                                                   | 10-20 mg/kg IM <sup>193</sup>                   | Psittacines/anecdotal dosing                                                                                                                                                                                                                                                                 |
|                                                   | 12-15 mg/kg IM <sup>145</sup>                   | Pigeons/duration 20-30 min; useful for radiography                                                                                                                                                                                                                                           |
|                                                   | 36 mg/kg IP <sup>43,445,446</sup>               | Psittacines, waterfowl, raptors/immobilization                                                                                                                                                                                                                                               |
| Atipamezole (Antisedan,                           | —                                               | $\alpha_2$ adrenergic antagonist; 1:1 volume reversal of dexmedetomidine and medetomidine is general rule; although the same effects would be expected as with                                                                                                                               |

|                                            |                                                               |                                                                                                                                                                                                                                        |
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| Pfizer)                                    |                                                               | medetomidine (no longer available), there is no data available on the efficacy of this volume of atipamezole reversal of dexmedetomidine in birds                                                                                      |
|                                            | 2.5-5× medetomidine dose IM, IV <a href="#">488,714,715</a>   | Psittacines, pigeons, raptors, geese/righting reflex regained 2-10 min after administration                                                                                                                                            |
|                                            | 0.18-0.28 mg/kg IV <a href="#">487</a>                        | Mallard ducks                                                                                                                                                                                                                          |
|                                            | 0.25-0.38 mg/kg IM <a href="#">488</a>                        | Psittacines, mallard ducks                                                                                                                                                                                                             |
|                                            | 0.25-0.5 mg/kg IM <a href="#">43,488,619,714</a>              | Most species, including psittacines, pigeons                                                                                                                                                                                           |
|                                            | 0.4 mg/kg ½ IV, ½ SC <a href="#">441,488</a>                  | Ostriches                                                                                                                                                                                                                              |
|                                            | 1.3-1.6 mg/kg IV <a href="#">376</a>                          | Chickens                                                                                                                                                                                                                               |
|                                            | 6 mg/kg intranasally <a href="#">832</a>                      | Ring-necked parakeets/dose divided evenly between nares and given slowly; significantly reduced recumbency time after detomidine administration                                                                                        |
| Atropine sulfate                           | —                                                             | Anticholinergic agent                                                                                                                                                                                                                  |
|                                            | 0.01-0.02 mg/kg SC, IM, IV <a href="#">6</a>                  | Most species/preanesthetic                                                                                                                                                                                                             |
|                                            | 0.04-0.1 mg/kg SC, IM, IV, IO, IT <a href="#">133,363,655</a> | Most species/bradycardia; higher doses with CPR                                                                                                                                                                                        |
| Azaperone (Stresnil, Janssen)              | —                                                             | Butyrophenone neuroleptic agent; see metomidate for combination; not available in the United States                                                                                                                                    |
|                                            | 0.73 mg/kg IM <a href="#">810</a>                             | Ratites/sedation                                                                                                                                                                                                                       |
|                                            | 1 mg/kg IV <a href="#">102</a>                                | Ostriches/premedication                                                                                                                                                                                                                |
|                                            | 1-4 mg/kg IM <a href="#">102</a>                              | Ostriches/sedation                                                                                                                                                                                                                     |
| Benzocaine (Trocaine, Cetyline Industries) | Topical anesthesia <a href="#">135</a>                        | Small birds/minor wound repair                                                                                                                                                                                                         |
| Bupivacaine HCl                            | —                                                             | Local anesthetic agent; 4-6 hr duration of action in mammals, <a href="#">153</a> may be shorter acting in some birds; <a href="#">491</a> recommend minimizing dose to limit potential toxic effects; bupivacaine combination follows |
|                                            | 2 mg/kg infused SC <a href="#">491</a>                        | Mallard ducks/PD; high plasma levels at 6 and 12 hr post-administration so possible for delayed toxicity                                                                                                                               |
|                                            | 2-8 mg/kg perineurally <a href="#">88</a>                     | Mallard ducks/variable effectiveness for brachial plexus nerve block                                                                                                                                                                   |
|                                            | 2-10 mg/kg infused into                                       | Eider ducks/high bupivacaine dose toxicity                                                                                                                                                                                             |

|                                       |                                                                                        |                                                                                                                                                                                                                               |
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|                                       | incision site <sup>542</sup>                                                           | or cumulative toxicity of bupivacaine and ketoprofen may have occurred                                                                                                                                                        |
|                                       | 3 mg/0.3 mL saline injected IA <sup>352</sup>                                          | Chickens/arthritis                                                                                                                                                                                                            |
|                                       | 5 mg/kg with 10 µg/kg epinephrine perineurally <sup>229</sup>                          | Chickens/unsuccessful brachial plexus nerve block                                                                                                                                                                             |
|                                       | 50:50 mixture with dimethyl sulfoxide topically <sup>289</sup>                         | Chickens/topical anesthesia; applied to amputated beaks                                                                                                                                                                       |
| Bupivacaine HCl (B)/medetomidine (Me) | (B) 2 mg/kg + (Me) 0.5 µg/kg perineurally radial and medianoulnar nerve <sup>734</sup> | Prairie falcons/significant wing droop after 15 min                                                                                                                                                                           |
| Buprenorphine HCl                     | —                                                                                      | Opioid agonist-antagonist <sup>c</sup>                                                                                                                                                                                        |
|                                       | 0.05-1 mg/kg IA <sup>284</sup>                                                         | Chickens/PD; no significant antinociceptive effects                                                                                                                                                                           |
|                                       | 0.1 mg/kg IM <sup>597</sup>                                                            | African grey parrots/PD; ineffective for analgesia                                                                                                                                                                            |
|                                       | 0.25 mg/kg IM q7h <sup>598</sup>                                                       | African grey parrots/PD; dose required to reach human analgesic plasma concentrations; analgesic effect not evaluated at this dose                                                                                            |
|                                       | 0.25-0.5 mg/kg IM <sup>276</sup>                                                       | Pigeons/PD; dose-dependent increased withdrawal time from noxious stimulus for 2-5 hr                                                                                                                                         |
| Butorphanol tartrate                  | —                                                                                      | Opioid agonist-antagonist; <sup>c</sup> PO bioavailability <10% in Hispaniolan Amazon parrots, PO route not recommended; <sup>712</sup> butorphanol combination follows; see ketamine and xylazine for combination            |
|                                       | 0.05-0.25 mg/kg IV <sup>810</sup>                                                      | Ratites                                                                                                                                                                                                                       |
|                                       | 0.5 mg/kg IM, IV q1-4h <sup>668,711</sup>                                              | Raptors/PD: $t_{1/2}$ IM, IV very short (approx. 1-2 hr); more rapid clearance and shorter $t_{1/2}$ when given IV medial metatarsal v. than IV median ulnar v.                                                               |
|                                       | 0.5-4 mg/kg IM, IV q1-4h <sup>163,276,363,420,597,668,711,744</sup>                    | Most species, including psittacines/no isoflurane-sparing effects detected in harlequin ducks when administered IM 15 min prior to induction; <sup>541</sup> in raptors doses of >1 mg/kg can cause recumbency <sup>363</sup> |
|                                       |                                                                                        | African grey parrots, cockatoos, blue-fronted Amazon parrots/PD; significantly reduced ED <sub>50</sub> of isoflurane for African                                                                                             |

|                                              |                                                                                             |                                                                                                                                                                                                                                                                 |
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|                                              | 1-2 mg/kg IM <sup><a href="#">162-164,228</a></sup>                                         | greys and cockatoos but not for Amazon parrots; African grey parrots had more significant reduction of withdrawal response to electrical stimulus at 2 mg/kg                                                                                                    |
|                                              | 2-5 mg/kg IM, IV q2-3h <sup><a href="#">420,712,744</a></sup>                               | Hispaniolan Amazon parrots/PD: low mean plasma concentrations at 2 hr post-injection; PD: withdrawal from electrical stimuli reduced after 2 mg/kg IM; effective pre-emptive analgesia with sevoflurane anesthesia for endoscopy <sup><a href="#">420</a></sup> |
|                                              | 3 mg/kg (pre-medication) + 75 µg/kg/min IV CRI (maintenance) <sup><a href="#">458</a></sup> | Psittacines/PD; significantly reduced isoflurane MAC                                                                                                                                                                                                            |
|                                              | 3-6 mg/kg IM <sup><a href="#">597</a></sup>                                                 | Hispaniolan Amazon parrots/PD; electrical stimuli to assess withdrawal thresholds                                                                                                                                                                               |
| Butorphanol (B)/midazolam (Mi)               | (B) 1 mg/kg + (Mi) 1 mg/kg <sup><a href="#">229</a></sup>                                   | Chickens/adequate sedation for lateral recumbency                                                                                                                                                                                                               |
| Carfentanil (Wildnil, Wildlife Laboratories) | —                                                                                           | Super-potent opioid agonist; <sup><a href="#">c</a></sup> carfentanil combination follows                                                                                                                                                                       |
|                                              | 0.024 mg/kg IM <sup><a href="#">511,763</a></sup>                                           | Ostriches (free-ranging)/darted from helicopter                                                                                                                                                                                                                 |
|                                              | 0.03 mg/kg IM <sup><a href="#">384</a></sup>                                                | Ratites                                                                                                                                                                                                                                                         |
| Carfentanil (C)/xylazine (X)                 | (C) 3 mg + (X) 150 mg IM per ostrich <sup><a href="#">636</a></sup>                         | Ostriches (free-ranging)/darted from helicopter                                                                                                                                                                                                                 |
| Desflurane (Suprane, Baxter)                 | —                                                                                           | Fluorine halogenated ether; fast induction, rapid recovery; <sup><a href="#">337</a></sup> currently no studies evaluating its use in any avian species                                                                                                         |
| Detomidine (Dormosedan, Pfizer)              | —                                                                                           | α <sub>2</sub> adrenergic agonist                                                                                                                                                                                                                               |
|                                              | 0.3 mg/kg IM <sup><a href="#">142,819</a></sup>                                             | Chickens, rock partridges/marked sedation; significant decrease in HR and RR, decrease in cloacal temperature, and prolonged recoveries (260 ± 17.6 min) in partridges                                                                                          |
|                                              | 12 mg/kg intranasally <sup><a href="#">832</a></sup>                                        | Ring-necked parakeets/dose divided into each nare and given slowly; sedation <3 min but did not allow dorsal recumbency or manipulation; reversal with atipamezole significantly reduced time to recovery                                                       |
|                                              | 12-15 mg intranasally <sup><a href="#">833</a></sup>                                        | Canaries/dose divided into each nare and given slowly; higher dose prolonged sedation but could not place in dorsal recumbency; prolonged duration of effect (257.5 ± 1.5 min); completely reversed with                                                        |

|                                             |                                                             |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
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| Dexmedetomidine HCl<br>(Dexdomitor, Pfizer) | —                                                           | yohimbine intranasally<br>$\alpha_2$ agonist; active optical enantiomer of racemic compound medetomidine; $\frac{1}{2}$ the dose of medetomidine but same volume due to concentration has been used as a general guideline, <sup>d</sup> although the same effects would be expected as with medetomidine (no longer available); limited data on the efficacy and safety of dexmedetomidine in birds, and to date appears to be seldom used clinically in birds, especially psittacines; see thiafentanil for combination |
|                                             | 25 $\mu$ g/kg IM <sup>715</sup>                             | Common buzzards/adequate restraint to prevent reaction to handling but did not allow for intubation; loss of righting reflex = $3.5 \pm 1$ min; no arrhythmias, excitement, or major adverse effects noted; complete reversal with atipamezole                                                                                                                                                                                                                                                                            |
|                                             | 75 $\mu$ g/kg IM <sup>715</sup>                             | Common kestrels/adequate restraint to prevent reaction to handling but did not allow for intubation; loss of righting reflex = $7 \pm 1.2$ min; no arrhythmias, excitement, or major adverse effects noted; complete reversal with atipamezole                                                                                                                                                                                                                                                                            |
| Diazepam                                    | —                                                           | Benzodiazepine; used alone for sedation, seizure control, tranquilization, and/or appetite stimulation; IM administration may cause severe muscle irritation and absorption may be delayed; reversal with flumazenil; see ketamine for combinations                                                                                                                                                                                                                                                                       |
|                                             | 0.05-0.5 mg/kg IV <sup>6</sup>                              | Most species                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
|                                             | 0.1-0.3 mg/kg IV <sup>384,640</sup>                         | Ratites/tranquilization; smooth anesthetic recovery                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
|                                             | 0.2-0.5 mg/kg IM <sup>6,193</sup>                           | Most species/premedication; onset in 15-20 min                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
|                                             | 0.25-0.5 mg/kg IM, IV q24h $\times$ 2-3 days <sup>776</sup> | Raptors/appetite stimulant                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
|                                             | 0.5 mg/kg PO <sup>513</sup>                                 | Passerines/calms fractious species while improving acceptance to a novel captive diet; oral solution (1 mg/mL, Roxane Laboratories) works best                                                                                                                                                                                                                                                                                                                                                                            |
|                                             | 0.5-1 mg/kg IM, IV q8-12h <sup>43</sup>                     | Raptors, waterfowl/sedation; anticonvulsant                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |
|                                             | 1-2 mg/kg IV <sup>413</sup>                                 | Ostriches/administer just prior to recovery from Telazol to counter its undesirable                                                                                                                                                                                                                                                                                                                                                                                                                                       |

|                                             |                                                                        |                                                                                                                                                                                                                                          |
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|                                             |                                                                        | effects                                                                                                                                                                                                                                  |
|                                             | 2.5-4 mg/kg PO <sup><a href="#">672</a></sup>                          | Most species/sedation                                                                                                                                                                                                                    |
|                                             | 5 mg/kg PO <sup><a href="#">267</a></sup>                              | Ostriches/standing sedation                                                                                                                                                                                                              |
|                                             | 5 mg/kg IV <sup><a href="#">267,511</a></sup>                          | Emus, rheas/sedation                                                                                                                                                                                                                     |
|                                             | 6 mg/kg IM <sup><a href="#">819</a></sup>                              | Rock partridges/decrease in cloacal temperature, prolonged recoveries (149 ± 8.3 min)                                                                                                                                                    |
|                                             | 12 mg/kg intranasally <sup><a href="#">832</a></sup>                   | Ring-necked parakeets/dose divided into each nare and given slowly; time to onset 3.5 ± 1.2 min, dorsal recumbency 11.0 ± 6.4 min; not sedate enough for any manipulation; flumazenil intranasally significantly reduced recumbency time |
|                                             | 12.5-15.6 mg/kg <sup><a href="#">833</a></sup>                         | Canaries/dose divided into each nare and given slowly; dorsal recumbency for approx. 35 min; flumazenil intranasally significantly reduced recumbency time                                                                               |
| Diprenorphine (Rickett and Coleman)         | 0.04-0.06 mg/kg IV <sup><a href="#">708</a></sup>                      | Ostriches/opioid antagonist                                                                                                                                                                                                              |
| Dobutamine                                  | —                                                                      | β <sub>1</sub> -adrenergic agonist, with weak β <sub>2</sub> activity, and selective α <sub>1</sub> activity; used to treat anesthetic-induced hypotension                                                                               |
|                                             | 15 µg/kg/min IV <sup><a href="#">721</a></sup>                         | Hispaniolan Amazon parrots/PD; significant increase in direct arterial pressure within 4-7 min                                                                                                                                           |
| Dopamine HCl                                | —                                                                      | Catecholamine neurotransmitter activating dopamine receptors; inotropic vasopressor used to treat anesthetic-induced hypotension                                                                                                         |
|                                             | 7-10 µg/kg/min IV <sup><a href="#">721</a></sup>                       | Hispaniolan Amazon parrots/PD; significant increase in direct arterial pressure within 4-7 min; greater effects on direct arterial pressures than dobutamine                                                                             |
| Etorphine HCl (M-99, Wildlife Laboratories) | —                                                                      | Super-potent opioid agonist; <sup><a href="#">c</a></sup> may be inadequate when used as sole agent; <sup><a href="#">384</a></sup> etorphine combination follows                                                                        |
|                                             | 0.025 mg/kg IM <sup><a href="#">511</a></sup>                          | Ostriches                                                                                                                                                                                                                                |
| Etorphine (E)/acepromazine (A)              | (E) 0.04-0.07 mg/kg + (A) 0.19 mg/kg IM <sup><a href="#">708</a></sup> | Ostriches (10-12 mo of age)                                                                                                                                                                                                              |
|                                             | (E) 3.6 mg/bird + (A) 15 mg/bird IM <sup><a href="#">708</a></sup>     | Ostriches                                                                                                                                                                                                                                |
| Etorphine                                   | (E) 0.04 mg/kg + (A) 0.16                                              | Ostriches/sedation for simple procedures                                                                                                                                                                                                 |



|                                                   |                                                                                     |                                                                                                                                                                             |
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| (E)/acepromazine                                  | mg/kg + (X) 0.66 mg/kg                                                              | lasting 10-20 min                                                                                                                                                           |
| (A)/xylazine (X)<br>Etorphine (E)/ketamine<br>(K) | IM <sup>708</sup><br>(E) 6-12 mg/bird IM + (K)<br>200-300 mg/bird IM <sup>384</sup> | Ostriches (adults)                                                                                                                                                          |
| Fentanyl citrate                                  | —                                                                                   | Short-acting $\mu$ opioid agonist <sup>c</sup>                                                                                                                              |
|                                                   | 0.2-0.5 $\mu$ g/kg/min IV <sup>600</sup>                                            | Red-tailed hawks/PD; reduced isoflurane MAC 31-55% in a dose-related manner, without significant effects on heart rate, blood pressure, $\text{paCO}_2$ , or $\text{paO}_2$ |
|                                                   | 0.02 mg/kg IM <sup>360</sup>                                                        | Cockatoos/PK; PD; rapid absorption, elimination; no effect withdrawal to thermal, electrical stimulus                                                                       |
|                                                   | 0.2 mg/kg SC <sup>360</sup>                                                         | Cockatoos/PK; PD; some analgesia; large dose and volume; hyperactivity first 15-30 min in some birds                                                                        |
|                                                   | 0.5-1 mg/kg IA <sup>284</sup>                                                       | Chickens/PD; no effect on pain behavior                                                                                                                                     |
| Flumazenil                                        | —                                                                                   | Benzodiazepene antagonist                                                                                                                                                   |
|                                                   | 0.018-0.028 mg/kg IV <sup>487</sup>                                                 | Mallard ducks                                                                                                                                                               |
|                                                   | 0.02-0.1 mg/kg IM, IV <sup>6,488</sup>                                              | Most species                                                                                                                                                                |
|                                                   | 0.05 mg/kg intranasally <sup>488,503</sup>                                          | Mallard ducks, Hispaniolan Amazon parrots                                                                                                                                   |
|                                                   | 0.1 mg/kg IM <sup>175</sup>                                                         | Quail/PD; reversed midazolam in 1.4-1.8 min                                                                                                                                 |
|                                                   | 0.13 mg/kg intranasally <sup>832</sup>                                              | Ring-necked parakeets/dose divided evenly between nares and given slowly, significantly reduced recumbency time                                                             |
|                                                   | 0.25-0.31 mg/kg intranasally <sup>833</sup>                                         | Canaries/dose divided evenly between nares and given slowly, significantly reduced recumbency time                                                                          |
| Gabapentin                                        | —                                                                                   | GABA analogue, used to treat human neuropathic pain                                                                                                                         |
|                                                   | 3 mg/kg PO q24h <sup>742</sup>                                                      | Senegal parrot/analgesia used with fluoxetine so difficult to determine sole efficacy; bird appeared sedated 3 days after initiation of administration                      |
|                                                   | 10 mg/kg PO q12h <sup>192,193</sup>                                                 | Little corella/analgesia long term (>90 days); sole analgesic for self-mutilation; no adverse effects noted                                                                 |
|                                                   | 11 mg/kg PO q12h <sup>734</sup>                                                     | Prairie falcon/long term (>90 days) analgesia adjunct to multi-modal therapy for self-mutilation; bird exhibited neurological signs, diarrhea when dosed at                 |

|                |                                                   |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
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|                |                                                   | 110 mg/kg but no adverse effects at 82 mg/kg                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
| Glycopyrrolate | —                                                 | Anticholinergic agent; slower onset than atropine                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
|                | 0.01-0.02 mg/kg IM, IV <sup>6,337</sup>           | Most species/preanesthetic; rarely indicated                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
|                | 0.04 mg/kg IV <sup>810</sup>                      | Ratites                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
| Isoflurane     | —                                                 | Inhalant anesthetic agent of choice in birds; dose-dependent hypotension with all inhalants; raptors, macaws may be more likely to exhibit isoflurane-induced arrhythmias <sup>6</sup>                                                                                                                                                                                                                                                                                                                    |
|                | 0.5-4% (usually 1.5-2%) <sup>70</sup>             | Ostriches/use following preanesthetic medication                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
|                | 1.115% <sup>745</sup>                             | Emus/PD; minimum anesthetic concentration                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
|                | 1.3% <sup>477,478</sup>                           | Cranes, ducks/minimum anesthetic concentration                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
|                | 1.44 ± 0.07% <sup>163</sup>                       | Cockatoos/PD; ED <sub>50</sub>                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
|                | 2.05 ± 0.45% <sup>600</sup>                       | Red-tailed hawks/PD; minimum anesthetic concentration                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
|                | 3-5% <sup>70</sup>                                | Ostriches/when used without preanesthetic medication                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
|                | 3-5% induction, 1.5-2.5% maintenance <sup>6</sup> | Most species                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
| Ketamine HCl   | —                                                 | Dissociative anesthetic; seldom used as sole agent because of poor muscle relaxation and prolonged (up to 3 hr), violent recovery; <sup>652</sup> may produce excitation or convulsions in pigeons, gallinules, water rails, golden pheasants, Hartlaub's turaco, ratites, and vultures; <sup>384,710</sup> may fail to produce general anesthesia in some species including great horned owls, snowy owls, Cooper's hawks, sharp-shinned hawks, and waterfowl; <sup>6</sup> ketamine combinations follow |
|                | 5 mg/kg IV q10min prn <sup>384</sup>              | Ratites/maintenance                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
|                | 5-30 mg/kg IM, IV <sup>43,259,337</sup>           | Raptors/sedation                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
|                | 11.1 mg/kg IM <sup>511</sup>                      | Ostriches                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
|                | 15-25 mg/kg IM, IV <sup>337</sup>                 | Waterfowl                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
|                |                                                   | Psittacines, pigeons, ratites,                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |



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|                               | 20-50 mg/kg SC, IM, IV <sup><a href="#">193,384,445</a></sup>                  | waterfowl/restraint 30-60 min; smaller species require a higher dose; large birds tend to recover more slowly                                                            |
|                               | 25 mg/kg IM <sup><a href="#">384,511</a></sup>                                 | Emus/may need to supplement 5-9 mg/kg IV q10min                                                                                                                          |
|                               | 50 mg/kg IO <sup><a href="#">408</a></sup>                                     | Pigeons/provided effective anesthesia                                                                                                                                    |
|                               | 50-100 mg/kg PO in bait <sup><a href="#">43,63,149</a></sup>                   | Raptors/sedation to catch an escaped bird; place in a 30 g piece of meat                                                                                                 |
| Ketamine (K)/acepromazine (A) | (K) 10-25 mg/kg + (A) 0.5-1 mg/kg IM <sup><a href="#">844</a></sup>            | Most species/high dose for birds <250 g                                                                                                                                  |
| Ketamine (K)/diazepam (D)     | (K) 2-5 mg/kg IV + (D) 0.25 mg/kg IV <sup><a href="#">102,153</a></sup>        | Ostriches/ketamine may be given 15-30 min after diazepam                                                                                                                 |
|                               | (K) 3-8 mg/kg + (D) 0.5-1 mg/kg IM <sup><a href="#">341</a></sup>              | Eagles, vultures                                                                                                                                                         |
|                               | (K) 5-10 mg/kg + (D) 0.1-0.2 mg/kg IV <sup><a href="#">692</a></sup>           | Ratites/induction                                                                                                                                                        |
|                               | (K) 5-25 mg/kg + (D) 0.5-2 mg/kg IV <sup><a href="#">844</a></sup>             | Psittacines/lower end of range is preferred                                                                                                                              |
|                               | (K) 5-30 mg/kg IM + (D) 0.5-2 mg/kg IM, IV <sup><a href="#">70</a></sup>       | Most species                                                                                                                                                             |
|                               | (K) 8-15 mg/kg + (D) 0.5-1 mg/kg IM <sup><a href="#">341</a></sup>             | Falcons                                                                                                                                                                  |
|                               | (K) 10-25 mg/kg + (D) 0.5-1 mg/kg IM, IV <sup><a href="#">693</a></sup>        | Pigeons/lower end of range administered IV is preferred                                                                                                                  |
|                               | (K) 10-40 mg/kg IV + (D) 1-1.5 mg/kg IM, IV <sup><a href="#">446,659</a></sup> | Raptors, waterfowl/induction or surgical anesthesia (rapid bolus may produce apnea, arrhythmia, and increased risk of death)                                             |
|                               | (K) 10-50 mg/kg + (D) 0.5-2 mg/kg IM <sup><a href="#">844</a></sup>            | Psittacines/improved muscle relaxation                                                                                                                                   |
|                               | (K) 20 mg/kg + (D) 1 mg/kg IV <sup><a href="#">159</a></sup>                   | Toucans/short procedures (15-20 min)                                                                                                                                     |
|                               | (K) 75 mg/kg IM + (D) 2.5 mg/kg IV <sup><a href="#">127</a></sup>              | Chickens/diazepam given 10 min after ketamine; pain reflexes elicited at all times; recovery in 90-100 min                                                               |
|                               | (K) 75 mg/kg IM + (D) 2.5 mg/kg IV <sup><a href="#">498</a></sup>              | White leghorn cockerels/diazepam administered 5 min before ketamine for typhlectomy; smooth induction/recovery, some limb contracture, hypothermia, hypoxia, hypercapnia |
| Ketamine                      | —                                                                              | Medetomidine no longer available; see dexmedetomidine                                                                                                                    |

|                                                     |                                                                                          |                                                                                                                                                                                                                                                                              |
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| (K)/butorphanol<br>(B)/medetomidine (Me)            | (K) 3 mg/kg + (B) 1 mg/kg +<br>(Me) 40 µg/kg IM <sup><a href="#">866</a></sup>           | Psittacines/premedication or supplement to<br>isoflurane; reduces isoflurane requirement<br>and improves ventilation                                                                                                                                                         |
|                                                     | (K) 50 mg + (B) 50 µg +<br>(Me) 50 µg IM per pigeon <sup><a href="#">34</a></sup>        | Pigeons/PD; satisfactory anesthesia in 7/8<br>pigeons; HR, RR decreased within 10 min<br>following M + B injection; arrhythmias 3/8<br>pigeons; cloacal temperature decreased<br>gradually during anesthesia                                                                 |
| Ketamine<br>(K)/medetomidine (Me)                   | —                                                                                        | Unreliable level of sedation in pigeons at<br>(K) 5 mg/kg + (Me) 80 µg/kg IM; <sup><a href="#">619</a></sup><br>medetomidine not currently available, but<br>can be compounded                                                                                               |
|                                                     | (K) 1.5-2 mg/kg + (Me) 60-<br>85 µg/kg IM, IV <sup><a href="#">119,446</a></sup>         | Pigeons, waterfowl/sedation                                                                                                                                                                                                                                                  |
|                                                     | (K) 2 mg/kg + (Me) 80 µg/kg<br>IM <sup><a href="#">441</a></sup>                         | Ostriches/sedation                                                                                                                                                                                                                                                           |
|                                                     | (K) 2-4 mg/kg + (Me) 25-75<br>µg/kg IV <sup><a href="#">375</a></sup>                    | Raptors                                                                                                                                                                                                                                                                      |
|                                                     | (K) 2.5-7 mg/kg + (Me) 50-<br>100 µg/kg IV <sup><a href="#">374</a></sup>                | Large psittacines                                                                                                                                                                                                                                                            |
|                                                     | (K) 3-5 mg/kg + (Me) 50-<br>100 µg/kg IM <sup><a href="#">375</a></sup>                  | Raptors                                                                                                                                                                                                                                                                      |
|                                                     | (K) 3-7 mg/kg + (Me) 75-<br>150 µg/kg IM <sup><a href="#">374</a></sup>                  | Large psittacines                                                                                                                                                                                                                                                            |
|                                                     | (K) 5-10 mg/kg + (Me) 100-<br>200 µg/kg IM, IV <sup><a href="#">375</a></sup>            | Geese                                                                                                                                                                                                                                                                        |
|                                                     | (K) 25 mg/kg + (M) 100<br>µg/kg IM <sup><a href="#">664</a></sup>                        | Psittacines/anesthesia                                                                                                                                                                                                                                                       |
| Ketamine<br>(K)/medetomidine<br>(Me)/midazolam (Mi) | (K) 10 mg/kg + (Me) 50<br>µg/kg + (Mi) 2 mg/kg<br>IV <sup><a href="#">487,488</a></sup>  | Mallard ducks/PD; medetomidine not<br>currently available; anesthesia of 30 min<br>duration; reverse with atipamezole,<br>flumazenil intranasally; regimen considered<br>unsafe due to acidosis, bradypnea, apnea<br>and in 1/12 birds, death <sup><a href="#">488</a></sup> |
| Ketamine (K)/midazolam<br>(Mi)                      | (K) 10-40 mg/kg + (Mi) 0.2-<br>2 mg/kg SC, IM <sup><a href="#">193,502,511,844</a></sup> | Most species, including psittacines                                                                                                                                                                                                                                          |
|                                                     | (K) 20 mg/kg + (Mi) 4<br>mg/kg IM <sup><a href="#">147</a></sup>                         | Psittacines/anesthesia                                                                                                                                                                                                                                                       |
|                                                     | (K) 40-50 mg/kg + (Mi) 3.65<br>mg/kg intranasally <sup><a href="#">832</a></sup>         | Ring-necked parakeets/dose divided into<br>each nare and given slowly; onset of action<br>< 3 min, dorsal recumbency for 70.7 ± 46.7<br>min, recovery times reduced with                                                                                                     |

|                                             |                                                                                                        |                                                                                                                                                                                     |
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|                                             |                                                                                                        | flumazenil intranasally                                                                                                                                                             |
|                                             | (K) 50 mg/kg IV + (Mi) 2 mg/kg IM <sup><a href="#">498</a></sup>                                       | White leghorn cockerels/midazolam administered 5 min before ketamine for typhlectomy; hypoxia, hypercapnia, torticollis, dyspnea, salivation noted; prolonged recovery (92-105 min) |
| Ketamine (K)/midazolam (Mi)/butorphanol (B) | (Mi) 0.2 mg/kg + (B) 0.4 mg/kg IM followed by (K) $8.7 \pm 0.5$ mg/kg IV <sup><a href="#">42</a></sup> | Ostriches/PD; anesthesia; followed by intubation and isoflurane anesthesia                                                                                                          |
| Ketamine (K)/tiletamine/zolazepam (Tz)      | (K) 15 mg/kg + (Tz) 10 mg/kg IM <sup><a href="#">435</a></sup>                                         | Raptors/anesthesia                                                                                                                                                                  |
| Ketamine (K)/xylazine (X)                   | —                                                                                                      | Often associated with cardiac depressive effects and rough recoveries                                                                                                               |
|                                             | (K) 0.45 mg/kg + (X) 25 mg/kg IM <sup><a href="#">511</a></sup>                                        | Ostriches                                                                                                                                                                           |
|                                             | (K) 2-3 mg/kg IV + (X) 5-10 mg/kg IM <sup><a href="#">102</a></sup>                                    | Ostriches                                                                                                                                                                           |
|                                             | (K) 2-5 mg/kg IV + (X) 0.25 mg/kg IV <sup><a href="#">102</a></sup>                                    | Ostriches                                                                                                                                                                           |
|                                             | (K) 2.2-3.3 mg/kg + (X) 2.2 mg/kg IM <sup><a href="#">384</a></sup>                                    | Ratites/administer xylazine 10-15 min before ketamine                                                                                                                               |
|                                             | (K) 4.4 mg/kg + (X) 2.2 mg/kg IV <sup><a href="#">363,445</a></sup>                                    | Psittacines, raptors                                                                                                                                                                |
|                                             | (K) 5 mg/kg + (X) 1 mg/kg IM <sup><a href="#">70</a></sup>                                             | Ostriches                                                                                                                                                                           |
|                                             | (K) 8 mg/kg IV + (X) 4 mg/kg IM <sup><a href="#">19</a></sup>                                          | Ostriches/ketamine administered 20 min after xylazine; as an adjunct to isoflurane anesthesia produced sufficient surgical plane of anesthesia                                      |
|                                             | (K) 10 mg/kg + (X) 0.5-1 mg/kg IM <sup><a href="#">18,515</a></sup>                                    | Ratites, turkey vultures                                                                                                                                                            |
|                                             | (K) 10 mg/kg + (X) 2 mg/kg IV <sup><a href="#">498</a></sup>                                           | White leghorn cockerels/for typhlectomy; smooth induction/recovery, optimal to excellent surgical anesthesia                                                                        |
|                                             | (K) 10-15 mg/kg + (X) 2 mg/kg IM <sup><a href="#">540</a></sup>                                        | Owls                                                                                                                                                                                |
|                                             | (K) 10-50 mg/kg + (X) 1-10 mg/kg IM <sup><a href="#">153,540</a></sup>                                 | Psittacines/birds <250 g require dose at higher end of range                                                                                                                        |
|                                             | (K) 15-20 mg/kg + (X) 1.5 mg/kg IM <sup><a href="#">540</a></sup>                                      | African grey parrots                                                                                                                                                                |

|                                                     |                                                                                |                                                                                                                                                                                                                                                                                                     |
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|                                                     | (K) 20 mg/kg + (X) 1 mg/kg IV <sup><a href="#">479</a></sup>                   | Pekin ducks/bradypnea, acidemia, hypoxemia, moderate hyperthermia                                                                                                                                                                                                                                   |
|                                                     | (K) 20 mg/kg + (X) 1-2 mg/kg IV slow bolus <sup><a href="#">159</a></sup>      | Toucans                                                                                                                                                                                                                                                                                             |
|                                                     | (K) 20-30 mg/kg + (X) 2.5-4 mg/kg IM <sup><a href="#">147,540</a></sup>        | Psittacines/in cockatoos, use (X) 2.5-3.5 mg/kg                                                                                                                                                                                                                                                     |
|                                                     | (K) 25 mg/kg + (X) 1 mg/kg IM <sup><a href="#">794</a></sup>                   | Guinea fowl/lateral recumbency 1-6 min, adequate anesthesia, arousal after yohimbine administration $1.4 \pm 0.7$ min                                                                                                                                                                               |
|                                                     | (K) 25 mg/kg + (X) 2.5 mg/kg IM <sup><a href="#">540</a></sup>                 | Cockatiels                                                                                                                                                                                                                                                                                          |
|                                                     | (K) 25-30 mg/kg + (X) 2 mg/kg IM <sup><a href="#">540</a></sup>                | Falcons, hawks                                                                                                                                                                                                                                                                                      |
|                                                     | (K) 30-40 mg/kg + (X) 6.5-10 mg/kg IM <sup><a href="#">339,540</a></sup>       | Budgerigars                                                                                                                                                                                                                                                                                         |
|                                                     | (K) 40-50 mg/kg + (X) 10 mg/kg intranasally <sup><a href="#">832</a></sup>     | Ring-necked parakeets/dose divided evenly between nares and given slowly; time to sedation, $7.7 \pm 1.4$ min; dorsal recumbency, $12.2 \pm 14.1$ min; yohimbine IM shortened recovery                                                                                                              |
| Ketamine (K)/xylazine (X)/acepromazine (A)          | (K) 34 mg/kg + (X) 0.2 mg/kg + (A) 0.1 mg/kg IM <sup><a href="#">384</a></sup> | Ostriches                                                                                                                                                                                                                                                                                           |
| Ketamine (K)/xylazine (X)/alfaxalone/alfadolone (A) | (K) 5 mg/kg + (X) 1 mg/kg + (A) 12-17 mg/kg IV <sup><a href="#">511</a></sup>  | Ostriches                                                                                                                                                                                                                                                                                           |
| Ketamine (K)/xylazine (X)/diazepam (D)              | (K) 25 mg/kg + (X) 3 mg/kg + (D) 4 mg/kg IM <sup><a href="#">539</a></sup>     | Roosters/use with caution; significant decreases in HR, RR, cloacal temperatures; prolonged recoveries (up to 4 hr)                                                                                                                                                                                 |
| Ketamine (K)/xylazine (X)/midazolam (Mi)            | (K) 15 mg/kg + (X) 2.5 mg/kg + (Mi) 0.3 mg/kg IM <sup><a href="#">14</a></sup> | Guinea fowl/midazolam improved anesthetic quality                                                                                                                                                                                                                                                   |
| Lidocaine                                           | —                                                                              | Local anesthetic agent with a duration of action in mammals of 90-200 min; <sup><a href="#">153</a></sup> toxic effects have been documented in birds at overall lower total doses of lidocaine (2.7-3.3 mg/kg) than in dogs; <sup><a href="#">352</a></sup> may need to dilute 1:10 in small birds |
|                                                     | 1-3 mg/kg <sup><a href="#">6,363</a></sup>                                     | Most species                                                                                                                                                                                                                                                                                        |
|                                                     | 15 mg/kg + 3.8 µg/kg lidocaine perineurally <sup><a href="#">88</a></sup>      | Mallard ducks/variable effectiveness for brachial plexus nerve block                                                                                                                                                                                                                                |
|                                                     |                                                                                |                                                                                                                                                                                                                                                                                                     |

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|                                                     | 20 mg/kg with 10 µg/kg epinephrine perineurally <sup>229</sup> | Chickens/unsuccessful brachial plexus nerve block                                                                                                                                                                                                         |
| Medetomidine (Domitor, Pfizer)                      | —                                                              | No longer commercially available; can be compounded; dosages listed here as a general guide for possible dexmedetomidine dosing                                                                                                                           |
|                                                     |                                                                | α <sub>2</sub> adrenergic agonist; 80-2000 µg/kg IM was associated with inadequate sedation in the pigeon; <sup>619,714</sup> 100 µg/kg IM did not immobilize ostrich chicks; <sup>826</sup> see ketamine, bupivacaine, and thiafentanil for combinations |
|                                                     | 60-85 µg/kg IM <sup>4</sup>                                    | Psittacines                                                                                                                                                                                                                                               |
|                                                     | 150-350 µg/kg IM <sup>43</sup>                                 | Raptors                                                                                                                                                                                                                                                   |
|                                                     | 250-350 µg/kg PO <sup>376</sup>                                | Chickens/sedation; 60 µg given to male birds, 40 µg given to female birds; average time of sedation was 6 min                                                                                                                                             |
| Meperidine HCl                                      | —                                                              | Short-acting opioid agonist <sup>c</sup>                                                                                                                                                                                                                  |
|                                                     | 1-4 mg/kg IM <sup>672,810</sup>                                | Most species, including ratites (at 1 mg/kg)/sedation; analgesia                                                                                                                                                                                          |
| Methohexital sodium (Brevital, JHP Pharmaceuticals) | —                                                              | Rapid, ultra-short acting barbiturate anesthetic                                                                                                                                                                                                          |
|                                                     | 4-8 mg/kg IV <sup>511</sup>                                    | Poultry                                                                                                                                                                                                                                                   |
|                                                     | 5-10 mg/kg IV <sup>511</sup>                                   | Ducks                                                                                                                                                                                                                                                     |
| Metomidate HCl (Hypnodil, Janssen)                  | —                                                              | Medetomidate combination follows                                                                                                                                                                                                                          |
|                                                     | 15-20 mg/kg IM <sup>413</sup>                                  | Ostriches/with or without azaperone                                                                                                                                                                                                                       |
|                                                     | 4 g/cup of bait (usually corn) <sup>511</sup>                  | Wild turkeys                                                                                                                                                                                                                                              |
| Metomidate (M)/azaperone (A)                        | (M) 10-20 mg/kg + (A) 3.3-6.6 mg/kg IM <sup>511,826</sup>      | Ostriches, including chicks/azaperone not available in United States                                                                                                                                                                                      |
| Midazolam HCl                                       | —                                                              | Benzodiazepine; shorter acting than diazepam; see butorphanol and ketamine for combinations                                                                                                                                                               |
|                                                     | 0.1-2 mg/kg IM, IV <sup>6</sup>                                | Most species/premedication at lower doses, onset approx. 15 min when administered IM                                                                                                                                                                      |
|                                                     | 0.15 mg/kg IV <sup>384</sup>                                   | Ostriches/rapid sternal recumbency in adults                                                                                                                                                                                                              |
|                                                     | 0.2 mg/kg SC, IM <sup>43</sup>                                 | Psittacines/for use in combination with ketamine                                                                                                                                                                                                          |
|                                                     | 0.3-0.4 mg/kg IM <sup>384,515</sup>                            | Ostriches, emus/premedication; sedation of                                                                                                                                                                                                                |

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|                  | 0.4 mg/kg IV <sup><a href="#">384</a></sup>                   | adult emus<br>Emus                                                                                                                                                                            |
|                  | 0.5-1 mg/kg IM, IV q8h <sup><a href="#">43</a></sup>          | Raptors/anticonvulsant                                                                                                                                                                        |
|                  | 2 mg/kg intranasally <sup><a href="#">503</a></sup>           | Hispaniolan Amazon parrots/mild to moderate sedation in 3 min; reduced vocalizations, struggling and defensive behaviors for 15 min; reversed with intranasally flumazenil                    |
|                  | 2 mg/kg IM <sup><a href="#">821</a></sup>                     | Canada geese/sedation for 15-20 min                                                                                                                                                           |
|                  | 2-6 mg/kg IM <sup><a href="#">175</a></sup>                   | Quail/PD; mild to heavy sedation                                                                                                                                                              |
|                  | 4-6 mg/kg IM <sup><a href="#">387</a></sup>                   | Waterfowl                                                                                                                                                                                     |
|                  | 5 mg/kg IV <sup><a href="#">154</a></sup>                     | Turkeys, chickens, ring-necked pheasants, bobwhite quail/PD rapid absorption, $t_{1/2}$ = 0.42, 1.45, 1.90, and 9.71 hr for turkeys, chickens, bobwhite quail, and pheasants, respectively    |
|                  | 7.3-8.8 mg/kg intranasally <sup><a href="#">832,833</a></sup> | Ring-necked parakeets/dose divided into each nare and given slowly; time to onset, 3 min; dorsal recumbency, $57.7 \pm 24.4$ min; flumazenil intranasally significantly reduced recovery time |
|                  | 12.5-15.6 mg/kg intranasally <sup><a href="#">833</a></sup>   | Canaries/dose divided into each nare and given slowly; time to onset, < 3 min; dorsal recumbency, $17.1 \pm 5$ min; flumazenil intranasally significantly reduced recovery time               |
| Morphine sulfate | —                                                             | Opioid agonist; <sup><a href="#">c</a></sup> early work in chickens demonstrated confusing clinical dosage results                                                                            |
|                  | 1-3 mg/kg IA <sup><a href="#">284</a></sup>                   | Chickens/PD; no analgesic effect for arthritis noted                                                                                                                                          |
|                  | 2.5-3 mg/kg SC, IM q4h <sup><a href="#">673</a></sup>         | Galliformes/analgesia                                                                                                                                                                         |
|                  | 10-20 mg/kg IM <sup><a href="#">226</a></sup>                 | Japanese quail/PD; exhibited anti-nociceptive effects on foot withdrawal and pressure tests; no effect on locomotion, eating, drinking at these doses                                         |
| Nalbuphine HCl   | —                                                             | Opioid partial $\kappa$ -agonist and partial $\mu$ -antagonist; <sup><a href="#">c</a></sup> due to its low abuse potential, this opioid is currently not a DEA scheduled substance           |
|                  |                                                               | Hispaniolan Amazon parrots/PK, PD; excellent IM bioavailability; little sedation                                                                                                              |



|                                                     |                                                                                                                  |                                                                                                                                                                                                                                                                             |
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|                                                     | 12.5 mg/kg IM q2-3h <sup>415,713</sup>                                                                           | and no adverse effects; rapidly cleared after IM and IV dosing; thermal foot withdrawal threshold values increased $\geq 3$ hr; higher dosages (25, 50 mg/kg IM) did not significantly increase withdrawal values                                                           |
| Naloxone HCl                                        | —                                                                                                                | Opioid antagonist; shorter acting than naltrexone                                                                                                                                                                                                                           |
|                                                     | 0.01 mg/kg IV <sup>42</sup>                                                                                      | Ostriches                                                                                                                                                                                                                                                                   |
|                                                     | 2 mg IV q14-21h <sup>672,812</sup>                                                                               | Most species, including psittacines                                                                                                                                                                                                                                         |
| Naltrexone HCl<br>(Trexonil, Wildlife Laboratories) | —                                                                                                                | Opioid antagonist; longer acting than naloxone                                                                                                                                                                                                                              |
|                                                     | 300-330 mg IM, IV <sup>413,511,636</sup>                                                                         | Ostriches/opioid antagonist                                                                                                                                                                                                                                                 |
| Nitrous oxide                                       | —                                                                                                                | Sufficient oxygen must be provided to avoid hypoxic mixtures; may cause some cardiovascular depression; <sup>337</sup> do not use in birds with normal subcutaneous air pockets (e.g., pelicans, hornbills) or in birds with marginal respiratory reserves <sup>6,337</sup> |
| Nitrous oxide (N)/isoflurane (I)/vecuronium (V)     | 0.3 L/kg/min of oxygen and (N) (1:1, min 33% O <sub>2</sub> ) + (I) 1-2.4% + (V) 0.2 mg/kg IV <sup>427,428</sup> | Most species/mydriasis and anesthesia; gases are administered via air sac cannulation; vecuronium effective up to 256 min in pigeons                                                                                                                                        |
| Pentobarbital sodium                                | —                                                                                                                | Short-acting barbituate; see <a href="#">Table 5-17</a> for other indications                                                                                                                                                                                               |
|                                                     | 13.3 mg/kg IV <sup>511</sup>                                                                                     | Emus/premedicate with diazepam                                                                                                                                                                                                                                              |
| Propofol                                            | —                                                                                                                | IV sedative-hypnotic agent; intubation, ventilation, and supplemental oxygen is strongly recommended <sup>6,490,726</sup>                                                                                                                                                   |
|                                                     | 1-5 mg/kg IV <sup>193</sup>                                                                                      | Many species/give slowly for induction to minimize apnea; intubation and IPPV required                                                                                                                                                                                      |
|                                                     | 1.33 mg/kg IV <sup>43,363</sup>                                                                                  | Psittacines, raptors                                                                                                                                                                                                                                                        |
|                                                     | 2.9-4.7 mg/kg IV (induction); 0.4-0.55 mg/kg/min IV (maintenance) <sup>336</sup>                                 | Red-tailed hawks, great horned owls/PK, PD; minimal blood pressure effects, but ventilation significantly reduced; prolonged recoveries with moderate-to-severe excitatory CNS signs may occur in these species at these doses                                              |
|                                                     | 3 mg/kg IV (induction); 0.2 mg/kg/min IV (maintenance) <sup>441</sup>                                            | Ostriches/PD; anesthesia                                                                                                                                                                                                                                                    |
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|                                                                                   | 4 mg/kg IV (induction); 0.5 mg/kg/min IV (maintenance) <a href="#">501</a>                    | Barn owl/anesthesia                                                                                                                                                                         |
|                                                                                   | 5 mg/kg IV (induction); 0.5 mg/kg/min IV (maintenance) <a href="#">726</a>                    | Wild turkeys/PD; anesthesia                                                                                                                                                                 |
|                                                                                   | 5 mg/kg IV (induction); 1 mg/kg/min IV (maintenance) <a href="#">443</a>                      | Hispaniolan Amazon parrots/PD; recovery times ( $15.4 \pm 15.2$ min) were prolonged when compared with isoflurane; 6/10 birds had agitated recoveries; light anesthetic plane in 8/10 birds |
|                                                                                   | 6-14 mg/kg (induction); boluses prn <a href="#">542</a>                                       | Eider ducks/anesthesia with inhalant, bupivacaine, ketoprofen; significant mortality but high dose bupivacaine toxicity or cumulative bupivacaine/ketoprofen toxicity may have occurred     |
|                                                                                   | 8-10 mg/kg IV (induction); 1-4 mg/kg IV boluses prn (maintenance) <a href="#">487,488,490</a> | Mallard ducks, canvasback ducks/PD; anesthesia                                                                                                                                              |
|                                                                                   | 14 mg/kg IV <a href="#">237,363</a>                                                           | Pigeons, raptors/anesthesia; 2-7 min duration; severe respiratory depression and apnea documented in pigeons                                                                                |
|                                                                                   | 15 mg/kg IV (induction); 0.8 mg/kg/min IV (maintenance) <a href="#">489</a>                   | Canvasback ducks/PD; some excitement during induction; 2 deaths; significant reduction in ventilation                                                                                       |
| Ropivacaine (Ropi 0.75%, Crista'lia Chemical & Pharmaceutical, Sao Paulo, Brazil) | —                                                                                             | Local anesthetic; not currently available in the United States                                                                                                                              |
|                                                                                   | 7.5 mg/kg perinervally <a href="#">109</a>                                                    | Chickens/15 min to effect for brachial plexus nerve block; approx. 110 min anesthesia; no toxic effects noted at this dose                                                                  |
| Sevoflurane                                                                       | $2.21 \pm 0.32\%$ <a href="#">554</a>                                                         | Chickens/PD; minimum anesthetic concentration; dose-dependent hypotension noted                                                                                                             |
|                                                                                   | 4% maintenance <a href="#">428</a>                                                            | Pigeons/PD; shorter induction/recovery when compared with isoflurane                                                                                                                        |
|                                                                                   | 6% induction; 3.5% maintenance <a href="#">220</a>                                            | Crested caracara/PD; smooth induction/recovery; reduced RR and arterial blood pressures                                                                                                     |
|                                                                                   | Incremental increases up to 7% prn (induction) <a href="#">420,631</a>                        | Psittacines/anesthesia; similar to isoflurane; provides more rapid recovery; less incidence of ataxia during recovery <a href="#">337,427,631</a>                                           |
|                                                                                   |                                                                                               |                                                                                                                                                                                             |



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| Thiafentanil oxalate (Th)/dexmedetomidine (D)/tiletamine-zolazepam (Tz) | —                                                               | Ultra-short acting opioid agonist (Th) not currently available in the United States; alpha-2 agonist (D); dissociative anesthetic (Tz)                              |
|                                                                         | (Th) 7 mg + (D) 0.2 mg + (Tz) 100 mg IM per bird <sup>802</sup> | Greater rheas/anesthesia administered via remote injection, smooth induction/recovery; respiratory depression in 1/8 birds but recovered when reversed              |
| Thiafentanil oxalate (T)/medetomidine (Me)                              | —                                                               | Ultra-short acting opioid agonist (T); alpha-2 agonist (Me); neither drug currently available in the United States                                                  |
|                                                                         | (T) 0.175 mg/kg + (Me) 0.092 mg/kg IM <sup>164</sup>            | Adult emus/anesthesia via remote injection; rapid induction (6.8 min) and recovery (3.2 min)                                                                        |
| Tiletamine/zolazepam (Telazol, Fort Dodge)                              | —                                                               | Dissociative anesthetic associated with prolonged, rough recoveries; <sup>6</sup> see ketamine and thiafentanil for combinations                                    |
|                                                                         | 1-8 mg/kg IV <sup>384,540</sup>                                 | Ratite adults/induction and/or short procedures                                                                                                                     |
|                                                                         | 2-12 mg/kg IM <sup>466,511,770</sup>                            | Ratite adults/induction and/or short procedures; <sup>267</sup> recommend 3-5 mg/kg IM for captive birds and 5 mg/kg IM for free-ranging birds                      |
|                                                                         | 4-25 mg/kg IM <sup>149,722,826</sup>                            | Most species, including psittacines, raptors, ostriches, flamingos, waterfowl/sedation; dose generally decreases as body weight increases in waterfowl              |
|                                                                         | 5-10 mg/kg IM <sup>43,63,363,413,435,445,446</sup>              | Ostrich (chicks), raptors, psittacines/good immobilization                                                                                                          |
|                                                                         | 6.6 mg/kg IM <sup>722</sup>                                     | Swans                                                                                                                                                               |
|                                                                         | 9-30 mg/kg IM <sup>722</sup>                                    | Owls, wood partridges/restraint                                                                                                                                     |
|                                                                         | 10 mg/kg IM <sup>435,722</sup>                                  | Raptors                                                                                                                                                             |
|                                                                         | 15-22 mg/kg IM <sup>540,722</sup>                               | Budgerigars, emus                                                                                                                                                   |
|                                                                         | 40-80 mg/kg PO <sup>149</sup>                                   | Raptors                                                                                                                                                             |
|                                                                         | 80 mg/kg in feed <sup>377,870</sup>                             | Eurasian buzzards/sufficient in most birds to allow safe handling after 30-60 min; birds receiving drug in powder form reached a deeper plane of anesthesia quicker |
| Tolazoline HCl (Tolazine, Lloyd)                                        | —                                                               | α <sub>2</sub> adrenergic antagonist                                                                                                                                |
|                                                                         | 1 mg/kg IV <sup>413</sup>                                       | Ostriches                                                                                                                                                           |
|                                                                         | 15 mg/kg IV <sup>18,142,511</sup>                               | Raptors, including vultures                                                                                                                                         |
|                                                                         |                                                                 | Synthetic analog of codeine with opioid, α-                                                                                                                         |

|              |                                        |                                                                                                                                                                                                                                                                                                                                                                                               |
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| Tramadol HCl | —                                      | adrenergic, and serotonergic receptor activity; O-desmethyltramadol (M1) metabolite is more potent $\mu$ opiate agonist in mammals                                                                                                                                                                                                                                                            |
|              | 5 mg/kg PO, IV q12h <sup>751,752</sup> | Bald eagles/PK; similar plasma concentrations to humans for analgesia but analgesia not evaluated; PO bioavailability in bald eagles higher than in humans, dogs; <sup>752</sup> sedation evident after multiple dosing; monitor for sedation and reduce dose and/or frequency prn                                                                                                            |
|              | 7.5 mg/kg PO <sup>71</sup>             | Peafowl/PK; only 2/6 birds reached human tramadol analgesic concentrations; 5/6 maintained O-desmethyl-tramadol (M1) concentrations above human analgesic concentrations for 10-12 hr and 3/6 for 24 hr; analgesia not evaluated                                                                                                                                                              |
|              | 8-11 mg/kg PO q12h <sup>751,753</sup>  | Red-tailed hawks/PK; only 3 birds; 15 mg/kg PO q12h data model suggested more frequent dosing to achieve human analgesic plasma tramadol concentrations; analgesia not evaluated; <sup>751</sup> birds sedated after multiple dosing; monitor for sedation and reduce dose and/or frequency prn <sup>751</sup>                                                                                |
|              | 30 mg/kg PO q6h <sup>751,754</sup>     | Hispaniolan Amazon parrots/PK; similar plasma concentrations to humans for analgesia; effectively reduced thermal withdrawal response for 6 hr                                                                                                                                                                                                                                                |
| Xylazine     | —                                      | $\alpha_2$ adrenergic agonist not recommended by itself for tranquilization and seldom used in pet birds due to adverse effects—excitement, convulsions, bradycardia, arrhythmias, bradypnea, hypoxemia, hypercarbia, and death when used alone; reversible with yohimbine, atipamezole; most useful in ratites; <sup>337,710</sup> see butorphanol, etorphine, and ketamine for combinations |
|              | 0.2-1 mg/kg IM <sup>384,636</sup>      | Ratites/calming sedation                                                                                                                                                                                                                                                                                                                                                                      |
|              | 1 mg/kg IV <sup>479</sup>              | Pekin ducks                                                                                                                                                                                                                                                                                                                                                                                   |
|              | 1-2.2 mg/kg IM, IV <sup>43</sup>       | Raptors, psittacines/in combination with ketamine (1:3 or 1:5); still widely used in raptors in some countries                                                                                                                                                                                                                                                                                |
|              |                                        |                                                                                                                                                                                                                                                                                                                                                                                               |

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|                               | 1-20 mg/kg IM, IV <sup>119,363</sup><br>10 mg/kg IM <sup>819</sup> | Waterfowl, raptors/sedation<br>Rock partridges/good sedation; significant decrease in RR; decrease in cloacal temperature; prolonged recoveries (205 ± 22.2 min) |
|                               | 20 mg intranasally <sup>832</sup>                                  | Ring-necked parakeets/time to onset, 7.9 ± 2.8 min but sedation not adequate for manipulation; reversed with yohimbine intranasally successful                   |
|                               | 24-30 mg intranasally <sup>833</sup>                               | Canaries/heavy sedation; prolonged sedation but could not place in dorsal recumbency at either dose; reversed with yohimbine intranasally                        |
| Xylazine (X)/butorphanol (B)  | (X) 1.06-2.75 mg/kg + (B) 0.1-0.55 mg/kg IM <sup>466</sup>         | Ratites, including rheas/sedation, premedication; higher doses were needed in rheas                                                                              |
| Yohimbine HCl (Yobine, Lloyd) | —                                                                  | α <sub>2</sub> adrenergic antagonist; excitement and mortality observed at doses >1 mg/kg <sup>337</sup>                                                         |
|                               | 0.1-0.2 mg/kg IV <sup>43,119</sup>                                 | Psittacines, raptors, waterfowl                                                                                                                                  |
|                               | 0.1-0.2 mg/kg IM, IV <sup>363</sup>                                | Raptors                                                                                                                                                          |
|                               | 0.1-1 mg/kg <sup>6</sup>                                           | Most species                                                                                                                                                     |
|                               | 0.11-0.275 mg/kg IM, IV once <sup>339</sup>                        | Budgerigars                                                                                                                                                      |
|                               | 0.125 mg/kg IV <sup>384,413,636</sup>                              | Ratites                                                                                                                                                          |
|                               | 1 mg/kg IV <sup>794</sup>                                          | Guinea fowl                                                                                                                                                      |
|                               | 12 mg/kg intranasally <sup>832</sup>                               | Ring-necked parakeets/dose divided evenly between nares and administered slowly; successful reversal of xylazine intranasally                                    |
|                               | 12-15 mg/kg intranasally <sup>833</sup>                            | Canaries/dose divided evenly between nares and administered slowly; successful reversal of xylazine and detomidine                                               |

<sup>a</sup> For other analgesic recommendations refer to [Tables 5-6](#) (nonsteroidal antiinflammatory agents) and [Table 5-7](#) (hormones and steroids).

<sup>b</sup> The anesthetic agents of choice in most avian species are the inhalant agents, isoflurane and sevoflurane.

<sup>c</sup> All opioid agonists and agonist-antagonists may cause respiratory depression; profound bradypnea may occur with potent opioid agonists.

<sup>d</sup> The effects of the volume:volume use of the dexmedetomidine and medetomidine may not be equivalent, so the dose of dexmedetomidine may need to be adjusted based on clinical response.

TABLE 5-6 Nonsteroidal Antiinflammatory Agents Used in Birds.<sup>a-c</sup>

| Agent                          | Dosage                                          | Species/Comments                                                                                                                                    |
|--------------------------------|-------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------|
| Acetaminophen                  | 5 mg/L drinking water <sup>811</sup>            | Most species/antipyretic, analgesic; overdosage may be associated with hepatotoxicity                                                               |
| Aspirin (acetylsalicylic acid) | —                                               | Contraindicated with tetracycline, insulin, or allopurinol therapy <sup>5</sup>                                                                     |
|                                | 5 mg/kg PO q8h <sup>672,812</sup>               | Most species                                                                                                                                        |
|                                | 25 mg/kg IV <sup>38-40</sup>                    | Chickens, ostriches, ducks, turkeys, pigeons/PK; rapid clearance except longer $t_{1/2}$ in pigeon                                                  |
|                                | 50 mg/kg PO q8h <sup>210</sup>                  | Psittacines                                                                                                                                         |
|                                | 100-200 mg/kg IM <sup>351</sup>                 | Chickens/partially reduced arthritic behaviors after 1 hr                                                                                           |
|                                | 150 mg/kg PO <sup>550</sup>                     | Psittacines                                                                                                                                         |
|                                | 325 mg/250 mL drinking water <sup>210</sup>     | Most species/make fresh q8-12h; alters taste of water (may not be well accepted)                                                                    |
| Carprofen                      | —                                               | Caution should be used when administering to <i>Gyps</i> vultures <sup>166</sup>                                                                    |
|                                | 1 mg/kg SC <sup>519</sup>                       | Chickens/improved locomotion for at least 90 min postinjection                                                                                      |
|                                | 1-2 mg/kg PO, IM, IV q12-24h <sup>149,363</sup> | Most species, including raptors                                                                                                                     |
|                                | 2-10 mg/kg SC, IM <sup>43,147,210</sup>         | Psittacines, passerines, raptors                                                                                                                    |
|                                | 3 mg/kg IM q12h <sup>599</sup>                  | Hispaniolan Amazon parrots/PD; markedly reduced arthritis pain 2 hr postadministration, but short-term effect thus more frequent dosing recommended |
|                                | 5-10 mg/kg PO, IM <sup>387,446</sup>            | Raptors, Anseriformes, pigeons/postoperative analgesia                                                                                              |
|                                | 30 mg/kg IM <sup>351</sup>                      | Chickens/PD; arthritis painful behaviors reduced 1 hr post-treatment only with this high dose                                                       |
|                                |                                                 | Chickens/analgesia; dosage required to reach similar                                                                                                |

|                                                     |                                                       |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
|-----------------------------------------------------|-------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                                                     | 40 mg/kg body weight provided in feed <sup>171</sup>  | mammalian therapeutic plasma concentrations (8.3 µg/mL), but much lower plasma concentrations (0.28 µg/mL) provided some analgesia                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
| Celecoxib (Celebrex, Pfizer)                        | 10 mg/kg PO q24h × 6-24 wk <sup>169</sup>             | Psittacines/clinical proventricular dilatation disease; clinical improvement may be seen within 7-14 days                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
| Diclofenac                                          | —                                                     | Recent massive mortalities in three vulture species lead to banning of diclofenac on the Indian subcontinent; severe renal lesions suggested toxicity of the kidneys or the renal supportive vascular system <sup>166,524,555,573,783</sup>                                                                                                                                                                                                                                                                                                                                                                                                                                         |
|                                                     | 12.5 mg PO once <sup>43</sup>                         | Pigeons/arthritis                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
| Dimethylsulfoxide (DMSO) (90%) (Domoso, Fort Dodge) | 1 mL/kg topical to affected area q4-7d <sup>672</sup> | Most species/antiinflammatory, analgesic; systemic absorption; use gloves during application                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
| Dipyrone (Novin, Vedco)                             | 20-25 mg/kg SC, IM, IV q8-12h <sup>689,810</sup>      | Ratites/analgesic for intestinal disorders; antipyretic                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
| Flunixin meglumine                                  | —                                                     | Potential nephrotoxicity; hydration is essential; use only for short duration (<5 days); <sup>149</sup> 5 mg/kg led to renal ischemia and necrosis in Siberian cranes; <sup>596</sup> histologic lesions occurred in budgerigars administered 5.5 mg/kg and severity increased with duration of therapy; <sup>603</sup> histologic glomerular changes were demonstrated in bobwhite quail given doses as low as 0.1 mg/kg (severity of lesions was directly correlated to dose); <sup>421</sup> avoid in <i>Gyps</i> vultures; <sup>166</sup> IM administration caused muscle necrosis in mallard ducks; <sup>493</sup> regurgitation may occur after administration <sup>399</sup> |
|                                                     | 0.2 mg/kg IM <sup>810</sup>                           | Ratites                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
|                                                     | 0.5 mg/kg IM <sup>337</sup>                           | Most species, including psittacines                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
|                                                     | 1-10 mg/kg IM, IV q24h <sup>332,363,379,656</sup>     | Most species, including raptors, psittacines                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
|                                                     | 1.1 mg/kg IV <sup>38-40</sup>                         | Chickens, ostriches, ducks, turkeys, pigeons/PK; chickens had long half-life, but ostrich $t_{1/2}$ = 10 min                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
|                                                     | 1.1 mg/kg IM q12h <sup>1,3</sup>                      | Ostriches/myositis <sup>3</sup>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
|                                                     | 1.5 mg/kg IM q24h × 3 days <sup>102</sup>             | Ostriches                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
|                                                     | 3 mg/kg IM <sup>351</sup>                             | Chickens/PD; arthritis behaviors reduced 1 hr after treatment                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |

|                                           |                                                                |                                                                                                                                                                                                                                          |
|-------------------------------------------|----------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                                           | 5 mg/kg IM <sup><a href="#">493</a></sup>                      | Mallard ducks/PD; reduced thromboxane activity for 12 hr but muscle necrosis at injection site                                                                                                                                           |
|                                           | 5.5 mg/kg IM q24h × 3 or 7 days <sup><a href="#">603</a></sup> | Budgerigars/some renal changes at 3 days, 6/8 birds had tubular necrosis at 7 days                                                                                                                                                       |
| Ibuprofen                                 | —                                                              | Avoid in <i>Gyps</i> vultures <sup><a href="#">166</a></sup>                                                                                                                                                                             |
|                                           | 5-10 mg/kg PO q8-12h <sup><a href="#">210</a></sup>            | Psittacines/use pediatric suspension for small birds                                                                                                                                                                                     |
| Ketoprofen                                | —                                                              | Avoid in <i>Gyps</i> vultures, mortalities reported at clinical doses; <sup><a href="#">556</a></sup> 7 of 11 Cape Griffon vultures ( <i>Gyps coprotheres</i> ) administered 5 mg/kg PO died within 48 hr <sup><a href="#">558</a></sup> |
|                                           | 1 mg/kg IM q24h × 1-10 days <sup><a href="#">43,63</a></sup>   | Raptors, waterfowl                                                                                                                                                                                                                       |
|                                           | 1-5 mg/kg IM q12h <sup><a href="#">655</a></sup>               | Raptors                                                                                                                                                                                                                                  |
|                                           | 2 mg/kg PO, SC, IM, IV <sup><a href="#">294</a></sup>          | Japanese quail/PK, PD; poor bioavailability and rapid clearance after PO or IM administration                                                                                                                                            |
|                                           | 2-5 mg/kg PO, IM, IV q12-24h <sup><a href="#">542</a></sup>    | Eider ducks/high mortality in male ducks may be due to high bupivacaine dose or cumulative toxicity of bupivacaine and ketoprofen                                                                                                        |
|                                           | 2.5 mg/kg IM q24h × 3 or 7 days <sup><a href="#">603</a></sup> | Budgerigars/low frequency of glomerular congestion, degeneration/dilation of tubules occurred at 3-7 day treatment                                                                                                                       |
|                                           | 5 mg/kg IM q12h <sup><a href="#">492,493</a></sup>             | Mallard ducks/PD; inhibited thromboxane for approx. 12 hr                                                                                                                                                                                |
|                                           | 5-10 mg/kg IM, IV <sup><a href="#">119,542</a></sup>           | Waterfowl                                                                                                                                                                                                                                |
|                                           | 12 mg/kg IM <sup><a href="#">351</a></sup>                     | Chickens/reduced arthritic pain behaviors for 12 hr                                                                                                                                                                                      |
| Meloxicam (Metacam, Boehringer Ingelheim) | —                                                              | No reported mortalities in over 700 cases of 60 species of birds, including <i>Gyps</i> vultures, <sup><a href="#">166,783,784</a></sup> but few studies to date evaluating renal effects of higher doses                                |
|                                           | 0.1 mg/kg IM q24h × 3 or 7 days <sup><a href="#">603</a></sup> | Budgerigars/mild glomerular congestion and tubular degeneration at 3 and 7 days                                                                                                                                                          |
|                                           | 0.1-0.2 mg/kg PO, IM q24h <sup><a href="#">149,760</a></sup>   | Psittacines, raptors                                                                                                                                                                                                                     |
|                                           | 0.5 mg/kg IV <sup><a href="#">38,39</a></sup>                  | Chickens, ostriches, ducks, turkeys, pigeons/PK; variable distribution, ostrich had more rapid $t_{1/2}$ (0.5 hr) than other                                                                                                             |

|                |                                               |                                                                                                                                                                                                                                                                                           |
|----------------|-----------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                | 0.5 mg/kg PO<br>q12h <sup>d</sup>             | species studied<br>Psittacines/clinical proventricular dilatation disease                                                                                                                                                                                                                 |
|                | 0.5-1 mg/kg PO<br>q12h <sup>854</sup>         | Ring-necked parakeets/PK; no analgesic evaluation                                                                                                                                                                                                                                         |
|                | 1 mg/kg PO, IM,<br>IV q12h <sup>144,533</sup> | Hispaniolan Amazon parrots/PD; improved weight-bearing on arthritic limb compared with lower doses; PO lower bioavailability than parenteral; PO did not attain plasma concentrations similar to humans for analgesia; concentrations similar to humans for analgesia for IM, IV for 6 hr |
|                | 2 mg/kg IM q12h<br>× 14 days <sup>740</sup>   | Japanese quail/PD; unremarkable histologic and minimal biochemical changes                                                                                                                                                                                                                |
|                | 2 mg/kg IM,<br>PO <sup>557</sup>              | Cape Griffon vultures/PD; rapid metabolism and short elimination $t_{1/2}$ (<45 min), suggests low potential for drug accumulation                                                                                                                                                        |
| Phenylbutazone | —                                             | Caution with use in <i>Gyps</i> vultures, mortalities associated with use <sup>166</sup>                                                                                                                                                                                                  |
|                | 3.5-7 mg/kg PO<br>q8-12h <sup>210</sup>       | Psittacines                                                                                                                                                                                                                                                                               |
|                | 10-14 mg/kg PO<br>q12h <sup>810</sup>         | Ratites                                                                                                                                                                                                                                                                                   |
|                | 20 mg/kg PO<br>q8h <sup>671</sup>             | Raptors                                                                                                                                                                                                                                                                                   |
| Piroxicam      | —                                             | Indicated for chronic osteoarthritis; has been used to treat pain associated with chronic degenerative joint disease in cranes and other species                                                                                                                                          |
|                | 0.5 mg/kg PO<br>q12h <sup>210</sup>           | Psittacines                                                                                                                                                                                                                                                                               |
|                | 0.5-0.8 mg/kg PO<br>q12h <sup>e</sup>         | Whooping cranes/acute myopathy, chronic degenerative joint disease                                                                                                                                                                                                                        |

<sup>a</sup> Unless otherwise noted, drugs provide analgesic, antipyretic, and antiinflammatory effects.

<sup>b</sup> Nonsteroidal antiinflammatory agents may potentially cause gastrointestinal upset and hemorrhage as well as adverse renal effects ranging from fluid retention to renal failure.

<sup>c</sup> For other analgesic recommendations, refer to Tables 14-5 and 14-7.



<sup>d</sup> Rosenthal K. Personal communication. 2004.

<sup>e</sup> Paul-Murphy J. Personal communication. 2011.

TABLE 5-7 Hormones and Steroids Used in Birds.

| Agent                                          | Dosage                                                                               | Species/Comments                                                                                                                       |
|------------------------------------------------|--------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------|
| Adrenocorticotrophic hormone (ACTH)            | 1-2 U/kg IM <sup>689</sup>                                                           | Psittacines/ACTH stimulation test                                                                                                      |
|                                                | 16 U/bird<br>IM <sup>474,638,811,871</sup>                                           | Psittacines, including Amazon parrots, cockatoos, conures, lorikeets, macaws                                                           |
|                                                | 16-26 U/bird IM <sup>812</sup>                                                       | Psittacines/obtain baseline sample, administer ACTH, then sample in 1-2 hr; stress of handling and venipuncture may invalidate results |
|                                                | 50-125 µg/bird IM <sup>671</sup>                                                     | Pigeons                                                                                                                                |
| Boldenone undecylenate (Equipoise, Fort Dodge) | 1.1 mg/kg IM q21d <sup>810</sup>                                                     | Ratites/anabolic steroid                                                                                                               |
| Calcitonin                                     | 4 U/kg IM q12h × 14 days <sup>672</sup>                                              | Most species/reduce hypercalcemia (caused by cholecalciferol rodenticide toxicity)                                                     |
|                                                | 10 µg/kg IP <sup>864</sup>                                                           | Pigeons/significant reduction in plasma calcium over 5 days                                                                            |
| Chorionic gonadotropin (hCG)                   | 500-1000 U/kg IM on day 1, 3, 7 q3-6wk prn <sup>60,461,462,812</sup>                 | Most species/inhibits egg laying; administer on days 3 and 7 if hen lays after day 1                                                   |
| Deslorelin (Suprelorin, Peptech Animal Health) | —                                                                                    | GnRH agonist available as long-term implant; very little data available as to clinical use to date in birds; use with caution          |
|                                                | 4.7 mg or 9.4 mg implant placed SC intrascapularly <sup>148</sup>                    | Psittacines/no adverse reports with use                                                                                                |
| Dexamethasone <sup>a</sup>                     | 0.2-1 mg/kg IM, IV once or q12-24h × 2-7 days, then q48h × 5 days <sup>363,518</sup> | Most species, including raptors/antiinflammatory                                                                                       |
|                                                | 2-4 mg/kg IM, IV q12-24h <sup>47,97,812</sup>                                        | Most species, including ratites/shock, trauma                                                                                          |
|                                                | 2-8 mg/kg SC, IM, IV q12-24h <sup>577</sup>                                          | Cranes/reduce doses for long-term therapy                                                                                              |



|                                                                            |                                                                  |                                                                                                                                                                                                                   |
|----------------------------------------------------------------------------|------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                                                                            | 3 mg/kg IM, IV <sup><a href="#">47</a></sup>                     | Owls, hawks/PD; antiinflammatory; trauma; shock; enterotoxemia; one dose suppressed plasma corticosterone levels for 18 hr in hawks                                                                               |
| Dexamethasone sodium phosphate <sup><a href="#">a</a></sup>                | 2-4 mg/kg SC, IM, IV q6h-24h <sup><a href="#">399,696</a></sup>  | Most species, including raptors/head trauma, shock, hyperthermia; higher dose for shock, head trauma, and endotoxemia                                                                                             |
| Diethylstilbestrol diphosphate (Stilphostrol, Bayer)                       | 0.025-0.075 mg/kg IM <sup><a href="#">511,811</a></sup>          | Most species/narrow therapeutic index                                                                                                                                                                             |
|                                                                            | 0.4 mg/L drinking water <sup><a href="#">671</a></sup>           | Most species                                                                                                                                                                                                      |
| Dinoprost tromethamine                                                     | —                                                                | See prostaglandin F <sub>2</sub> α                                                                                                                                                                                |
| Dinoprostone                                                               | —                                                                | See prostaglandin E <sub>2</sub>                                                                                                                                                                                  |
| Ergonovine maleate                                                         | 0.06 mg/kg IM once <sup><a href="#">671</a></sup>                | Most species/administered with or without calcium for egg binding                                                                                                                                                 |
| Estradiol benzoate                                                         | —                                                                | Estrogens have been associated with severe adverse reactions in mammals; <sup><a href="#">614</a></sup> anemia, hypercholesterolemia, and hyperlipidemia were observed in penguins <sup><a href="#">348</a></sup> |
|                                                                            | 0.3-0.5 mg/kg PO q24h × 1 mo <sup><a href="#">348</a></sup>      | Penguins/induces molt                                                                                                                                                                                             |
|                                                                            | 1 mg/kg IM q24h × 12 days <sup><a href="#">348</a></sup>         | Mallard ducks/induces molt                                                                                                                                                                                        |
|                                                                            | 10-15 mg/kg IM q7d × 4 treatments <sup><a href="#">348</a></sup> | Penguins/induces molt                                                                                                                                                                                             |
| Fludrocortisone (Florinef acetate, Apothecon) <sup><a href="#">a</a></sup> | 0.4 mg/L drinking water <sup><a href="#">689</a></sup>           | Adrenal replacement surgery                                                                                                                                                                                       |
| Flumethasone (Flucort, Syntex) <sup><a href="#">a</a></sup>                | 1-1.5 mg/kg PO, SC, IM, IV <sup><a href="#">810</a></sup>        | Ratites/glucocorticoid; antiinflammatory                                                                                                                                                                          |
| Hydrocortisone <sup><a href="#">a</a></sup>                                | 3-4.5 mg/kg PO q12h <sup><a href="#">810</a></sup>               | Ratites                                                                                                                                                                                                           |
|                                                                            | 10 mg/kg IM q24h <sup><a href="#">811</a></sup>                  | Psittacines/hypoadrenocorticism                                                                                                                                                                                   |
|                                                                            | 10 mg/kg IV <sup><a href="#">147</a></sup>                       | Psittacines, passerines, raptors                                                                                                                                                                                  |
|                                                                            | 40-50 mg/kg IV q24h <sup><a href="#">810</a></sup>               | Ratites                                                                                                                                                                                                           |
| Insulin                                                                    | 0.002 U/bird IM q12-48h <sup><a href="#">862</a></sup>           | Budgerigars/NPH insulin                                                                                                                                                                                           |
|                                                                            | 0.01-0.1 U/bird IM q12-48h <sup><a href="#">638</a></sup>        | Amazon parrots/NPH insulin                                                                                                                                                                                        |
|                                                                            | 0.1-0.5 U/bird IM q24h                                           |                                                                                                                                                                                                                   |

|                                                                                                                                                                                                       |                                                                                 |                                                                                                                                                                                                                                                                                                                       |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                                                                                                                                                                                                       | or prn <sup>863</sup>                                                           | Toucans (toco)                                                                                                                                                                                                                                                                                                        |
|                                                                                                                                                                                                       | 0.5-3 U/kg IM <sup>812</sup>                                                    | Psittacines/NPH insulin                                                                                                                                                                                                                                                                                               |
|                                                                                                                                                                                                       | 1.4 U/kg IM q12-24h <sup>387,672</sup>                                          | Cockatiels, toco toucans/NPH insulin                                                                                                                                                                                                                                                                                  |
|                                                                                                                                                                                                       | 2 U/bird IM <sup>547,812</sup>                                                  | Toco toucans/ultralente or PZI insulin; adjust dose or frequency based on glucose curves                                                                                                                                                                                                                              |
| Leuprolide acetate (Lupron Depot, TAP Pharmaceuticals; Lupron Kit, Florida Infusion Pharmacy [single-dose leuprolide acetate available from Professional Arts Pharmacy, Baltimore, MD; 800-832-9285]) | —                                                                               | Synthetic GnRH agonist depot drug; prevents ovulation; may be indicated in some cases of sexually related feather picking or mutilation; <sup>287</sup> variable results obtained; in treating reproductive diseases, administration before onset of egg laying may be more successful than treatment during breeding |
|                                                                                                                                                                                                       | (no. of days for desired effect) × (52 or 156 µg/kg) = dosage IM <sup>527</sup> | Cockatiels/PD                                                                                                                                                                                                                                                                                                         |
|                                                                                                                                                                                                       | 100 µg/kg q14d for 3 treatments <sup>287,380</sup>                              | Most species/feather damaging behavior                                                                                                                                                                                                                                                                                |
|                                                                                                                                                                                                       | 200-800 µg/kg IM q3-6wk <sup>390</sup>                                          | Most species                                                                                                                                                                                                                                                                                                          |
|                                                                                                                                                                                                       | 250-750 µg/kg IM q2-6wk <sup>317</sup>                                          | Psittacines                                                                                                                                                                                                                                                                                                           |
|                                                                                                                                                                                                       | 375 µg/bird IM <sup>43,528</sup>                                                | Cockatiels/inhibit ovulation                                                                                                                                                                                                                                                                                          |
|                                                                                                                                                                                                       | 500 µg/kg IM q14d <sup>869</sup>                                                | Psittacines (>300 g)/for most problems, begin with 3 treatments                                                                                                                                                                                                                                                       |
|                                                                                                                                                                                                       | 700-800 µg/kg IM q14d <sup>81</sup>                                             | Psittacines                                                                                                                                                                                                                                                                                                           |
|                                                                                                                                                                                                       | 750 µg/kg IM q14d <sup>869</sup>                                                | Psittacines (≤300 g)/for most problems, begin with 3 treatments                                                                                                                                                                                                                                                       |
|                                                                                                                                                                                                       | 800 µg/kg IM <sup>419</sup>                                                     | Hispaniolan Amazon parrots/hormonal effects may taper off between 7 and 21 days after administration                                                                                                                                                                                                                  |
|                                                                                                                                                                                                       | 1250 µg/kg IM once <sup>348</sup>                                               | Penguins/induced molt in 1 of 2 birds dosed                                                                                                                                                                                                                                                                           |
| Levonorgestrel depot form (Levonorgestrel, Sigma Chemical)                                                                                                                                            | 40 mg/kg SC <sup>256,797</sup>                                                  | Japanese quail, turkeys/halts egg laying, but may cause ovostasis if already in oviduct; repeat in 60 days in turkeys                                                                                                                                                                                                 |
|                                                                                                                                                                                                       | —                                                                               | May induce molt; monitor blood levels and BW                                                                                                                                                                                                                                                                          |

|                             |                                                                                                                                                      |                                                                                                                                                                                                                                                                                                                                      |
|-----------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Levothyroxine (l-thyroxine) | 0.02 mg/kg PO q12-24h <a href="#">126,317</a>                                                                                                        | Pigeons, psittacines                                                                                                                                                                                                                                                                                                                 |
|                             | 1-100 µg/kg PO q12h × 4 wk <a href="#">43</a>                                                                                                        | Psittacines/induces molt                                                                                                                                                                                                                                                                                                             |
|                             | 5-200 µg/kg PO q12h <a href="#">686</a>                                                                                                              | Amazon parrots                                                                                                                                                                                                                                                                                                                       |
|                             | 20 µg/kg PO q12-24h <a href="#">638,812</a>                                                                                                          | Most species, including psittacines                                                                                                                                                                                                                                                                                                  |
|                             | 20-100 µg/kg PO q12h <a href="#">760</a>                                                                                                             | Psittacines                                                                                                                                                                                                                                                                                                                          |
|                             | 100 µg/bird PO 2×/wk <a href="#">102</a>                                                                                                             | Ostriches (<60 days of age)                                                                                                                                                                                                                                                                                                          |
|                             | 200-400 µg/bird PO q24h × 14 days <a href="#">786</a>                                                                                                | Chickens/induces molt                                                                                                                                                                                                                                                                                                                |
|                             | 200-1000 µg/kg PO q24h × 14 days <a href="#">149</a>                                                                                                 | Raptors                                                                                                                                                                                                                                                                                                                              |
|                             | BW 750-1000g:<br>25 µg q24h × 7 days<br>50 µg q24h × 7 days<br>75 µg q24h × 7 days<br>50 µg q24h × 7 days<br>25 µg q24h × 7 days <a href="#">363</a> | Raptors/induces molt; scale dose up or down by up to 50% for larger or smaller birds                                                                                                                                                                                                                                                 |
|                             | 280-830 µg/L drinking water (100 µg/120-360 mL) (mixed fresh daily for 5-10 days) <a href="#">638,812</a>                                            | Most species                                                                                                                                                                                                                                                                                                                         |
| Medroxyprogesterone acetate | —                                                                                                                                                    | This agent is not recommended; previously used for sexually related feather picking or chronic egg laying; high incidence of adverse effects, including lethargy, polydipsia, polyphagia, polyuria, immunosuppression, weight gain, liver disease, thromboembolism, diabetes mellitus, salpingitis, sudden death <a href="#">287</a> |
|                             | 5-25 mg/kg SC, IM, repeat q4-6wk prn <a href="#">317,811,812</a>                                                                                     | Psittacines/suppress ovulation; antipruritic (feather picking in male parrots)                                                                                                                                                                                                                                                       |
|                             | 5-50 mg/kg SC, IM q4-6wk <a href="#">43</a>                                                                                                          | Psittacines/higher dosages recommended for smaller birds (e.g., 50 mg/kg for 150 g bird) <a href="#">511</a>                                                                                                                                                                                                                         |
|                             | 15-30 mg/kg IM q7d × 4-5 treatments <a href="#">348,662</a>                                                                                          | Penguins/induces molt 60-90 days post-injection                                                                                                                                                                                                                                                                                      |

|                                                         |                                                                                     |                                                                                                                                                                                                                                                 |
|---------------------------------------------------------|-------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                                                         | 30 mg/kg SC, repeat in 90 days prn <sup><a href="#">147</a></sup>                   | Most species                                                                                                                                                                                                                                    |
|                                                         | 1000 mg/kg feed <sup><a href="#">692</a></sup>                                      | Pigeons/inhibits ovulation                                                                                                                                                                                                                      |
| Megestrol acetate (Ovaban, Schering)                    | —                                                                                   | Progestin providing nonspecific calming effects; <sup><a href="#">79</a></sup> side effects can be severe (diabetic-like); seldom used                                                                                                          |
|                                                         | 2.5 mg/kg PO q24h × 7 days then 1-2 ×/wk <sup><a href="#">64</a></sup>              | Psittacines/feather destructive behavior; sexual behavior problems                                                                                                                                                                              |
|                                                         | 10-20 mg/L drinking water × 7-10 days, then 1-2 ×/wk <sup><a href="#">292</a></sup> | Most species/feather picking                                                                                                                                                                                                                    |
| Methylprednisolone acetate <sup><a href="#">a</a></sup> | 0.5-1 mg/kg PO, IM <sup><a href="#">671,811,812</a></sup>                           | Most species/allergies (Amazon foot necrosis); <sup><a href="#">671</a></sup> use orally once weekly, then taper to once monthly, then stop                                                                                                     |
|                                                         | 200 mg/bird IM, repeat prn <sup><a href="#">810</a></sup>                           | Ratites (adults)                                                                                                                                                                                                                                |
| Mibolerone (Cheque Drops, Upjohn)                       | —                                                                                   | Potent anabolic and androgenic steroid                                                                                                                                                                                                          |
|                                                         | 85 µg/L drinking water <sup><a href="#">168</a></sup>                               | Psittacines/feather destructive behavior                                                                                                                                                                                                        |
| Nandrolene laurate (Laurabolin, Intervet)               | —                                                                                   | Testosterone derivative; used in the treatment of chronic, debilitating disease; may be hepatotoxic                                                                                                                                             |
|                                                         | 0.2-2 mg/kg IM once <sup><a href="#">511</a></sup>                                  | Most species                                                                                                                                                                                                                                    |
|                                                         | 0.4 mg/kg SC, IM once or q3wk <sup><a href="#">43</a></sup>                         | Psittacines, raptors, bustards                                                                                                                                                                                                                  |
| Oxytocin                                                | —                                                                                   | Use of oxytocin should be preceded by calcium administration for egg binding; contraindicated unless uterovaginal sphincter is well dilated and uterus is free of adhesions; used alone to stop uterine bleeding <sup><a href="#">683</a></sup> |
|                                                         | 0.5 U/kg, may repeat in 60 min <sup><a href="#">696</a></sup>                       | Psittacines/egg binding and dystocia                                                                                                                                                                                                            |
|                                                         | 2 U/kg IM <sup><a href="#">760</a></sup>                                            | Psittacines                                                                                                                                                                                                                                     |
|                                                         | 3-5 U/kg IM, may repeat q30min <sup><a href="#">43,63</a></sup>                     | Most species, including waterfowl, raptors                                                                                                                                                                                                      |
|                                                         | 5-10 U/kg IM once <sup><a href="#">755</a></sup>                                    | Psittacines/in some cases, multiple injections are recommended                                                                                                                                                                                  |
|                                                         | 20-30 U/bird IM q24h × 2 treatments <sup><a href="#">810</a></sup>                  | Ratites (adults)/egg binding                                                                                                                                                                                                                    |

|                                                                           |                                                                                              |                                                                                                                                                                                                                                          |
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| Prednisolone (prednisone) <sup>a</sup>                                    | 0.5-1 mg/kg IM, IV once <sup>671</sup>                                                       | Most species                                                                                                                                                                                                                             |
|                                                                           | 1-1.25 mg/kg PO q48h <sup>810</sup>                                                          | Ratites                                                                                                                                                                                                                                  |
|                                                                           | 2 mg/kg PO q12h <sup>64</sup>                                                                | Psittacines/inflammation                                                                                                                                                                                                                 |
|                                                                           | 2 mg/kg IM, IV q12-24h <sup>577</sup>                                                        | Cranes/shock, trauma, chronic lameness                                                                                                                                                                                                   |
|                                                                           | 2-4 mg/kg IM, IV <sup>363</sup>                                                              | Raptors/shock                                                                                                                                                                                                                            |
| Prednisolone sodium succinate (Solu-Delta-Cortef, Upjohn) <sup>a</sup>    | 0.5-1 mg/kg IM, IV <sup>696</sup>                                                            | Psittacines/antiinflammatory                                                                                                                                                                                                             |
|                                                                           | 1.5-2 mg/kg IM q12h <sup>810</sup>                                                           | Ratites/immunosuppression (see prednisolone for prolonged therapy)                                                                                                                                                                       |
|                                                                           | 2-4 mg/kg IM, IV once <sup>696</sup>                                                         | Psittacines/shock; trauma; endotoxemia; immunosuppression                                                                                                                                                                                |
|                                                                           | 5-8.5 mg/kg IV q1h <sup>810</sup>                                                            | Ratites/shock                                                                                                                                                                                                                            |
|                                                                           | 10-20 mg/kg IM, IV q15min prn <sup>133</sup>                                                 | Most species/head trauma; cardiopulmonary resuscitation                                                                                                                                                                                  |
|                                                                           | 30 mg/kg IV, then 15 mg/kg IV at 2 and 6 hr, then 2.5 mg/kg/hr × 24 hr <sup>59</sup>         | Most species/neurologic emergencies; start therapy within 4 hr of trauma                                                                                                                                                                 |
| Prednisone                                                                | —                                                                                            | See prednisolone                                                                                                                                                                                                                         |
| Prostaglandin E <sub>2</sub> (dinoprostone) (Prepidil Gel, Upjohn)        | 0.02-0.1 mg/kg applied topically to the uterovaginal sphincter <sup>43,317,364,683,696</sup> | Most species, including psittacines, raptors, waterfowl/dystocia; relaxes uterovaginal sphincter; lower dosage may be effective; freeze into aliquots                                                                                    |
|                                                                           | 1 mL/kg applied topically to the uterovaginal sphincter <sup>812</sup>                       | Psittacines                                                                                                                                                                                                                              |
| Prostaglandin F <sub>2α</sub> (Dinoprost tromethamine) (Lutalyse, Upjohn) | 0.02-0.1 mg/kg IM, intracloacal once <sup>702,811,812</sup>                                  | Most species, including psittacines, raptors, and waterfowl/dystocia; may be helpful when the egg is located distally and the uterovaginal sphincter is dilated; can result in uterine rupture, bronchoconstriction, hypertension, death |
| Somatostatin (Sandostatin, Sandoz)                                        | 0.003 mg/kg SC q12h <sup>406</sup>                                                           | Toucans (sulfur-breasted)/diabetes mellitus; clinical improvement observed; hyperglycemia and elevated glucagon levels persisted                                                                                                         |
| Stanozolol (Winstrol V, Pfizer)                                           | —                                                                                            | Anabolic steroid                                                                                                                                                                                                                         |
|                                                                           |                                                                                              |                                                                                                                                                                                                                                          |

|                                                  |                                                                                       |                                                                                                                                                                             |
|--------------------------------------------------|---------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                                                  | 0.5-1 mg/kg IM <a href="#">518</a><br>25-50 mg/kg IM q3-7d <a href="#">43,511,811</a> | Most species<br>Most species                                                                                                                                                |
|                                                  | 17 mg/L drinking water <a href="#">518</a>                                            | Most species                                                                                                                                                                |
| Tamoxifen citrate                                | —                                                                                     | Nonsteroidal antiestrogen                                                                                                                                                   |
|                                                  | 2 mg/kg PO q24h given on 2 consecutive days per wk for 38-46 wk <a href="#">486</a>   | Budgerigars/effects suggested by change in cere color from white/brown to blue; leukopenia was the most significant adverse effect                                          |
|                                                  | 40 mg/kg IM <a href="#">348,758</a>                                                   | Galliformes, ducks, penguins/induces molt                                                                                                                                   |
| Testosterone                                     | —                                                                                     | Anabolic steroid; may adversely affect spermatogenesis; contraindicated with hepatic or renal disease <a href="#">133</a>                                                   |
|                                                  | 2-8 mg/kg SC, IM once <a href="#">146</a>                                             | Most species/stimulates sexual behavior in the male; baldness in canaries                                                                                                   |
|                                                  | 8-8.5 mg/kg IM q7d prn <a href="#">16,43</a>                                          | Most species, including psittacines/anemia due to debilitation; to increase libido; use with caution                                                                        |
|                                                  | 10-15 mL stock solution/L drinking water × 5 days-2 mo <a href="#">692</a>            | Canaries/finish molt or regain singing; stock solution: 100 mg parenteral suspension/30 mL drinking water (3333 mg/L); mix fresh daily                                      |
| Thyroid releasing hormone                        | 15 µg/kg IM once <a href="#">146</a>                                                  | Most species                                                                                                                                                                |
| Thyroid stimulating hormone (thyrotropin; TSH)   | 0.1 U IM <a href="#">638</a>                                                          | Cockatiels                                                                                                                                                                  |
|                                                  | 0.2 U/kg IM <a href="#">298</a>                                                       | Macaws/PD; T <sub>4</sub> doubled in 6 of 11 birds 4 hr after receiving TSH                                                                                                 |
|                                                  | 1 U/kg IM <a href="#">298,638,871</a>                                                 | Hispaniolan parrots, blue-fronted Amazon parrots, African grey parrots, pigeons/PD; T <sub>4</sub> doubled in Hispaniolan and blue-fronted parrots 6 hr after receiving TSH |
|                                                  | 1-2 U/kg IM <a href="#">671,812</a>                                                   | Psittacines/obtain blood at 0 hr, then 4-6 hr after TSH stimulation                                                                                                         |
| Triamcinolone (Vetalog, Fort Dodge) <sup>a</sup> | 0.1-0.5 mg/kg IM once <a href="#">363,811</a>                                         | Most species, including raptors                                                                                                                                             |

<sup>a</sup> Steroid administration may predispose birds to aspergillosis and other mycoses. [363](#) Administration may also be associated with the development of polyuria/polydypsia/polyphagia, increased protein catabolism, glucosuria, and

diabetes mellitus. Toxic levels may be attained even with topical application.<sup>346</sup> Administration should ideally not exceed 5 days. Alternate day application of topical corticosteroids at double the daily dose is recommended if the drugs must be given long term. Rapid onset, shorter-acting drugs are generally less likely to cause serious adverse effects.<sup>347</sup>

TABLE 5-8 Nebulization Agents Used in Birds.<sup>a</sup>

| Agent                                           | Dosage                                                                                  | Species/Comments                                                                                                                                                                                                                                                                      |
|-------------------------------------------------|-----------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| N-acetyl-L-cysteine 10%-20% (Mucomyst, Bristol) | —                                                                                       | See amikacin, gentamicin, terbinafine for combinations                                                                                                                                                                                                                                |
|                                                 | 22 mg/mL sterile water until dissipated <sup>692</sup>                                  | Most species/mucolytic agent; tracheal irritation and reflex bronchoconstriction reported in mammals; use is preceded by bronchodilators in mammals <sup>78</sup>                                                                                                                     |
| Amikacin                                        | 5-6 mg/mL sterile water or saline × 15 min q8-12h <sup>132</sup>                        | Most species/discontinue if polyuria develops                                                                                                                                                                                                                                         |
|                                                 | 6 mg/mL sterile water and 1 mL acetylcysteine (20%) until dissipated q8h <sup>692</sup> | Most species                                                                                                                                                                                                                                                                          |
| Aminophylline                                   | 3 mg/mL sterile water or saline × 15 min <sup>692</sup>                                 | Most species/bronchial and pulmonary vasculature smooth muscle relaxation; incompatible with amikacin, cephalothin, clindamycin, erythromycin, oxytetracycline, methylprednisone, penicillin G, tetracycline; consult with specialized references for more information <sup>614</sup> |
| Amphotericin B (Fungizone, Squibb)              | —                                                                                       | May lead to hypokalemia; corticosteroids may exacerbate this effect; <sup>614</sup> minor systemic absorption with aerosol administration; can be nebulized long-term <sup>244</sup>                                                                                                  |
|                                                 | 0.1-1 mg/mL sterile water × 15 min <sup>692</sup>                                       | Raptors                                                                                                                                                                                                                                                                               |
|                                                 | 0.25 mg/mL saline × 15 min q12h <sup>331</sup>                                          | Hummingbirds/low efficacy; may cause weight loss                                                                                                                                                                                                                                      |
|                                                 | 0.3-1 mg/mL × 15 min q6-12h <sup>244</sup>                                              | Most species                                                                                                                                                                                                                                                                          |
|                                                 | 7-10 mg/mL saline <sup>132,695</sup>                                                    | Most species                                                                                                                                                                                                                                                                          |
| Carbenicillin (Geocillin, Roerig)               | 20 mg/mL saline × 15 min q12h <sup>696</sup>                                            | Psittacines/ <i>Pseudomonas</i> pneumonia; use in combination with parenteral aminoglycosides                                                                                                                                                                                         |



|                                                       |                                                                                                                                                             |                                                                                                                                          |
|-------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------|
| Cefotaxime                                            | 10 mg/mL saline × 10-30 min q6-12h <sup><a href="#">696</a></sup>                                                                                           | Most species                                                                                                                             |
| Ceftriaxone                                           | 40 mg/mL sterile water <sup><a href="#">132,405</a></sup>                                                                                                   | Poultry/PD                                                                                                                               |
|                                                       | 40 mg/mL sterile water and DMSO <sup><a href="#">405</a></sup>                                                                                              | Poultry/PD; 1 g ceftriaxone in 10 mL sterile water, plus 15 mL DMSO                                                                      |
|                                                       | 200 mg/mL sterile water and DMSO <sup><a href="#">405</a></sup>                                                                                             | Poultry/PD; 4 g ceftriaxone in 10 mL sterile water, plus 10 mL DMSO                                                                      |
| Chloramphenicol                                       | 13 mg/mL saline <sup><a href="#">132</a></sup>                                                                                                              | Most species/human health concerns; the development of aplastic anemia reported in humans; prohibited by the FDA for use in food animals |
| Clotrimazole (1%) (Lotrimin, Schering)                | 10 mg/mL propylene glycol or polyethylene glycol × 30-45 min q24h × 3 days, off 2 days, repeat prn for up to 4 mo <sup><a href="#">11,132,400,812</a></sup> | Most species/treatment of aspergillosis for stable patients without respiratory distress; can be toxic to psittacines at this dose       |
|                                                       | 10 mg/mL polyethylene glycol × 30-60 min <sup><a href="#">11,132,400</a></sup>                                                                              | Raptors, psittacines/used in combination with systemic amphotericin B, flucytosine, and itraconazole                                     |
|                                                       | 10% clotrimazole in propylene glycol with 5% DMSO <sup><a href="#">621</a></sup>                                                                            | Raptors                                                                                                                                  |
| Doxycycline hyclate (Vibramycin injection, Pfizer)    | 13 mg/mL saline <sup><a href="#">260</a></sup>                                                                                                              | Psittacines                                                                                                                              |
| Enilconazole (Imaverol, Janssen; Clinafarm, Schering) | 0.2 mg/5 mL saline q12h × 21 days <sup><a href="#">460</a></sup>                                                                                            | Most species, including raptors, psittacines                                                                                             |
|                                                       | 10 mg/mL sterile water <sup><a href="#">64,132</a></sup>                                                                                                    | Most species/antifungal                                                                                                                  |
|                                                       | 11 mg/mL saline <sup><a href="#">702</a></sup>                                                                                                              | Falcons/aspergillosis                                                                                                                    |
| Enrofloxacin (Baytril, Bayer)                         | 10 mg/mL saline <sup><a href="#">132,260</a></sup>                                                                                                          | Most species                                                                                                                             |
| Erythromycin                                          | 5-20 mg/mL saline × 15 min q8h <sup><a href="#">132,134,696</a></sup>                                                                                       | Most species                                                                                                                             |
| Gentamicin                                            | 3-6 mg/mL saline or sterile water and 1-2 mL acetylcysteine (20%) × 20 min q8h <sup><a href="#">111,692</a></sup>                                           | Most species, including cranes                                                                                                           |
|                                                       | 5 mg/mL saline × 15 min                                                                                                                                     |                                                                                                                                          |



|                                      |                                                                                                                                                            |                                                                                                  |
|--------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------|
|                                      | q8h <sup><a href="#">696</a></sup>                                                                                                                         | Most species                                                                                     |
| Lincomycin                           | 250 mg/mL water <sup><a href="#">132</a></sup>                                                                                                             | Most species                                                                                     |
|                                      | 250 mg aerosolized drug/m <sup>3</sup> chamber × 15-30 min <sup><a href="#">121</a></sup>                                                                  | Chickens/PD; antibiotic; therapeutic concentrations in blood, lungs, and trachea for up to 24 hr |
| Miconazole (Daktarin, Janssen)       | Nebulize 15 min q8h × 10 days <sup><a href="#">702</a></sup>                                                                                               | Raptors/aspergillosis                                                                            |
| Oxytetracycline                      | 2 mg/mL × 60 min q4-6h <sup><a href="#">208</a></sup>                                                                                                      | Parakeets/PD                                                                                     |
|                                      | 1 g/m <sup>3</sup> of air using a DeVilbiss ultrasonic nebulizer, or 0.075 g/m <sup>3</sup> of air using a Fogmaster fogger <sup><a href="#">822</a></sup> | Turkey poults                                                                                    |
| Piperacillin                         | 10 mg/mL saline × 10-30 min q6-12h <sup><a href="#">696</a></sup>                                                                                          | Most species                                                                                     |
| Polymyxin B sulfate                  | 66,000 U/mL saline <sup><a href="#">260</a></sup>                                                                                                          | Psittacines/poorly absorbed from respiratory epithelium                                          |
| Sodium chloride                      | —                                                                                                                                                          | Viscosity of respiratory secretions may be decreased by hydration <sup><a href="#">78</a></sup>  |
| Spectinomycin (Spectam, Ceva)        | 13 mg/mL saline <sup><a href="#">132,260</a></sup>                                                                                                         | Most species                                                                                     |
| Sterile water                        | —                                                                                                                                                          | Viscosity of respiratory secretions may be decreased by hydration <sup><a href="#">78</a></sup>  |
| Sulfadimethoxine (Albon, SmithKline) | 13 mg/mL saline <sup><a href="#">132,260</a></sup>                                                                                                         | Most species                                                                                     |
| Terbinafine                          | 500 mg and 1 mL acetyl-L-cysteine and 500 mL distilled water <sup><a href="#">170</a></sup>                                                                | Psittacines/aspergillosis                                                                        |
| Terbutaline                          | 0.01 mg/kg with 9 mL saline <sup><a href="#">455</a></sup>                                                                                                 | Psittacines/bronchodilation                                                                      |
| Tylosin (Tylan, Elanco)              | 10 mg/mL saline × 10-60 min q12h <sup><a href="#">260,696</a></sup>                                                                                        | Most species                                                                                     |
|                                      | 20 mg/mL DMSO or distilled water × 1 hr <sup><a href="#">468,469</a></sup>                                                                                 | Most species/pigeons, quail (PD)                                                                 |
|                                      | 20 mg/mL DMSO and 0.5 mL saline <sup><a href="#">147</a></sup>                                                                                             | Psittacines                                                                                      |

<sup>a</sup> Nebulization is an adjunctive therapy indicated for: rhinitis, sinusitis, tracheitis, pneumonia, airsacculitis, and syringeal aspergilloma, where there is air movement occurring in the patient's disease state; optimal particle size for deposition in the trachea is 2-10  $\mu\text{m}$ ; optimal particle size for peripheral airways is 0.5-5  $\mu\text{m}$ ; treatments of 30-45 min repeated q4-12h are recommended; caution: do not overhydrate airways.<sup>78</sup>

TABLE 5-9 Agents Used in the Treatment of Toxicologic Conditions of Birds.

| Agent                                                                                                 | Dosage                                              | Species/Comments                                                                                                                                                                           |
|-------------------------------------------------------------------------------------------------------|-----------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Atropine sulfate                                                                                      | —                                                   | Antidote for organophosphate (acetylcholinesterase inhibitor) toxicosis                                                                                                                    |
|                                                                                                       | 0.01-0.02 mg/kg<br>SC, IM <sup>78</sup>             | Most species/facilitates bronchodilation in acutely dyspneic animals; treatment of choice for anticholinesterase-induced respiratory distress                                              |
|                                                                                                       | 0.03-0.05 mg/kg<br>SC, IM, IV<br>q8h <sup>810</sup> | Ratites                                                                                                                                                                                    |
|                                                                                                       | 0.04-0.1 mg/kg<br>IM <sup>78</sup>                  | Psittacines/bronchodilation in acutely dyspneic animals; treatment of choice for anticholinesterase-induced respiratory distress                                                           |
|                                                                                                       | 0.05 mg/kg SC,<br>IM q1h <sup>702</sup>             | Psittacines                                                                                                                                                                                |
|                                                                                                       | 0.1 mg/kg IM, IV<br>q3-4h <sup>119,702</sup>        | Waterfowl, raptors                                                                                                                                                                         |
|                                                                                                       | 0.2-0.5 mg/kg<br>IM, IV q3-4h <sup>437</sup>        | Most species, including pigeons, raptors/organophosphate toxicosis                                                                                                                         |
| Bismuth sulfate<br>(Bismusal, Bimeda)                                                                 | 1-2 mL/kg<br>PO <sup>437,702</sup>                  | Most species/weak adsorbent, demulcent; may be useful for toxin removal                                                                                                                    |
| Botulinum type C<br>antitoxin (100 U/mL)<br>(National Wildlife<br>Health Center,<br>Madison, WI, USA) | 1 mL IP <sup>509,859</sup><br>once                  | Waterfowl/not commercially available; produced for experimental use in migratory birds <sup>587</sup>                                                                                      |
| Calcium EDTA<br>(edetate calcium<br>disodium)                                                         | —                                                   | Preferred initial chelator for lead and zinc toxicosis; may cause renal tubular necrosis in mammals; maintain hydration and monitor patient for PU/PD; SC, IM absorbed well <sup>614</sup> |
|                                                                                                       | 10-40 mg/kg IM<br>q12h $\times$ 5-10                | Raptors                                                                                                                                                                                    |

|                                                        |                                                                                  |                                                                                                                                                                                                                                                                                                                         |
|--------------------------------------------------------|----------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                                                        | days <sup>418</sup>                                                              |                                                                                                                                                                                                                                                                                                                         |
|                                                        | 20-70 mg/kg<br>IV <sup>176</sup>                                                 | Most species/empirical diagnosis; signs should resolve for up to 48 hr; diluted 1:4 in saline                                                                                                                                                                                                                           |
|                                                        | 25-50 mg/kg IV<br>q12h <sup>545</sup>                                            | Geese                                                                                                                                                                                                                                                                                                                   |
|                                                        | 30-35 mg/kg IM<br>q12h × 3-5 days,<br>off 3-4 days,<br>repeat prn <sup>437</sup> | Most species                                                                                                                                                                                                                                                                                                            |
|                                                        | 35 mg/kg IM, IV<br>q8h × 3-4 days,<br>off 2 days, repeat<br>prn <sup>397</sup>   | Raptors                                                                                                                                                                                                                                                                                                                 |
|                                                        | 40 mg/kg IM<br>q12h <sup>184</sup>                                               | Cockatiels/PD; reduces lead levels when used alone or with DMSA                                                                                                                                                                                                                                                         |
|                                                        | 50 mg/kg IM<br>q12h × up to 23<br>days <sup>706</sup>                            | Raptors/no deleterious effects observed                                                                                                                                                                                                                                                                                 |
| Charcoal, activated                                    | —                                                                                | Adsorbs toxins from the intestinal tract; may be mixed with hemicellulose to act as a bulk laxative to aid in the passage of ingested toxins; administration prior to cathartic use may help bind small particles of heavy metal; <sup>176</sup> see magnesium hydroxide ( <a href="#">Table 5-18</a> ) for combination |
|                                                        | 52 mg/kg PO<br>once <sup>529</sup>                                               | A component of oiled bird treatment; alternatively, may use bismuth                                                                                                                                                                                                                                                     |
|                                                        | 2000-8000 mg/kg<br>PO <sup>51,193,207</sup>                                      | Most species                                                                                                                                                                                                                                                                                                            |
| Deferiprone<br>(Ferriprox, Apotex,<br>Ontario, Canada) | 50 mg/kg PO<br>q12h × 30<br>days <sup>159,161,847,848</sup>                      | Toucans, pigeons, chickens/iron chelation; may produce rust-colored urates; supplemental zinc may be indicated; <sup>161</sup> an orphan drug in the United States                                                                                                                                                      |
|                                                        | 100 mg/kg SC<br>q24h <sup>580</sup>                                              | Starlings                                                                                                                                                                                                                                                                                                               |
| Deferoxamine<br>mesylate (Desferal,<br>Novartis)       | —                                                                                | Preferred iron chelator for hemochromatosis; may take 3 mo to see response; may cause reddish discoloration of urine; <sup>812</sup> avoid in birds with renal disease; <sup>812</sup> combine with a low iron diet <sup>161</sup>                                                                                      |
|                                                        | 20 mg/kg PO<br>initially, then IM<br>q4h until<br>recovery <sup>437</sup>        | Most species                                                                                                                                                                                                                                                                                                            |
|                                                        |                                                                                  |                                                                                                                                                                                                                                                                                                                         |

|                                                                                    |                                                                                                   |                                                                                                                                                                                                                 |
|------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                                                                                    | 20 mg/kg PO q4h until recovery <sup><a href="#">278,437</a></sup>                                 | Most species                                                                                                                                                                                                    |
|                                                                                    | 40 mg/kg IM q24h × 7 days <sup><a href="#">570</a></sup>                                          | Bali mynahs                                                                                                                                                                                                     |
|                                                                                    | 50 mg/kg IM q12h × 14 days <sup><a href="#">278</a></sup>                                         | Macaws                                                                                                                                                                                                          |
|                                                                                    | 100 mg/kg PO, SC, IM q24h up to 3.5 mo <sup><a href="#">152,159,534,812</a></sup>                 | Most species, including toucans                                                                                                                                                                                 |
| Dimercaprol (BAL in Oil, Becton Dickinson)                                         | 2.5-5 mg/kg IM q4h × 2 days, then q12h × 10 days or until recovery <sup><a href="#">812</a></sup> | Most species/heavy metal toxicosis; arsenical compound toxicosis; occasionally used for lead, mercury, and gold intoxication (if ingestion <2 hr) <sup><a href="#">268,614</a></sup>                            |
|                                                                                    | 25-35 mg/kg PO q12h × 3-5 wk <sup><a href="#">672</a></sup>                                       | Most species/give 5 days/wk                                                                                                                                                                                     |
| Dimercaptosuccinic acid (DMSA or succimer) (DMSA, Aldrich; Chemet, Bock Pharmacal) | —                                                                                                 | Oral chelator for lead or zinc; <sup><a href="#">828</a></sup> may be effective for mercury toxicity <sup><a href="#">399</a></sup>                                                                             |
|                                                                                    | 25-35 mg/kg PO q12h × 5 day/wk × 3-5 wk <sup><a href="#">399,437</a></sup>                        | Most species, including raptors/lead toxicosis                                                                                                                                                                  |
|                                                                                    | 25-35 mg/kg PO q24h × 10 days <sup><a href="#">147,437</a></sup>                                  | Psittacines, raptors/lead and zinc toxicosis                                                                                                                                                                    |
|                                                                                    | 30 mg/kg PO q12h × ≥7 days <sup><a href="#">357</a></sup>                                         | Most species/lead toxicosis                                                                                                                                                                                     |
|                                                                                    | 40 mg/kg PO q12h × 21 days <sup><a href="#">184</a></sup>                                         | Cockatiels/PD; lead toxicosis; reduces lead levels when used alone or in combination with CaEDTA; 80 mg/kg resulted in death in >60% of cockatiels                                                              |
| Diphenhydramine                                                                    | 2 mg/kg PO, IM q12h <sup><a href="#">764</a></sup>                                                | Macaws/used to treat extrapyramidal effects of clomipramine/haloperidol                                                                                                                                         |
| Magnesium hydroxide (M)/activated charcoal (C) (Milk of Magnesia, Roxane)          | (M) 10-12 mL + (C) 1 tsp powder <sup><a href="#">437</a></sup>                                    | Most species/cathartic; <sup><a href="#">a</a></sup> adsorbent                                                                                                                                                  |
| Magnesium sulfate (Epsom salts)                                                    | 500-1000 mg/kg PO q12-24h × 1-3 days <sup><a href="#">63,363,437,702</a></sup>                    | Raptors, waterfowl/cathartic used in lead toxicosis to reduce lead absorbtion; <sup><a href="#">a</a></sup> give 30 min after activated charcoal treatment or can cause lethargy <sup><a href="#">437</a></sup> |

|                                                                                                               |                                                                                  |                                                                                                                                                                                                                                                                        |
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| Melatonin                                                                                                     | 10 mg/kg in feed <sup><a href="#">590</a></sup>                                  | Chickens/aflatoxin exposure; tissue damage greatly reduced with co-administration                                                                                                                                                                                      |
| Penicillamine (Cuprimine, Merck)                                                                              | —                                                                                | Preferred chelator for copper toxicosis; may be used for lead, zinc, and mercury toxicosis <sup><a href="#">672</a></sup>                                                                                                                                              |
|                                                                                                               | 30 mg/kg PO q12h × ≥7 days <sup><a href="#">357</a></sup>                        | Most species/initially supplemented with CaEDTA once in severe neurologic disease                                                                                                                                                                                      |
|                                                                                                               | 30-55 mg/kg PO q12h × 7-14 days <sup><a href="#">63,399,418,437</a></sup>        | Most species, including raptors, waterfowl                                                                                                                                                                                                                             |
|                                                                                                               | 50-55 mg/kg PO q24h × 1-6 wk <sup><a href="#">147,176</a></sup>                  | Most species, including psittacines, raptors/use in combination with CaEDTA for several days followed by penicillamine × 3-6 wk <sup><a href="#">176</a></sup>                                                                                                         |
| Phytonadione                                                                                                  | —                                                                                | See vitamin K                                                                                                                                                                                                                                                          |
| Pralidoxime (2-PAM) (Protopam, Wyeth-Ayerst)                                                                  | —                                                                                | Administer within 24-36 hr of organophosphate intoxication; <sup><a href="#">812</a></sup> use lower dose in combination with atropine                                                                                                                                 |
|                                                                                                               | 10-100 mg/kg IM q24-48h or repeat once q6h <sup><a href="#">63,437,702</a></sup> | Psittacines, raptors, waterfowl                                                                                                                                                                                                                                        |
| Sodium sulfate (Glauber's salt) (GoLytely, Braintree; Anhydrous sodium sulfate, ACS Grade, Fisher Scientific) | —                                                                                | Cathartic; <sup><a href="#">a</a></sup> contraindicated with impaired gastrointestinal function; maintain hydration <sup><a href="#">812</a></sup>                                                                                                                     |
|                                                                                                               | 500 mg/kg PO q48h <sup><a href="#">184</a></sup>                                 | Cockatiels/PD; did not result in further decreases in lead concentrations when given to birds receiving CaEDTA alone or in combination with DMSA                                                                                                                       |
|                                                                                                               | 500-2000 mg/kg PO <sup><a href="#">671</a></sup>                                 | Most species                                                                                                                                                                                                                                                           |
|                                                                                                               | 2000 mg/kg PO q24h × 2 days <sup><a href="#">511,671</a></sup>                   | Most species                                                                                                                                                                                                                                                           |
| Succimer (Chemet, Bock Pharmacal)                                                                             | —                                                                                | See dimercaptosuccinic acid (DMSA)                                                                                                                                                                                                                                     |
| Tea (black tea leaves) (Ceylon CO <sub>2</sub> -decaffeinated tea leaves, Frontier Natural)                   | 8 g/kg diet <sup><a href="#">729</a></sup>                                       | Starlings/hepatic iron concentrations did not increase significantly in starlings on an iron-enriched diet when supplemented with tea leaves; tea containing approximately 20% (by weight) condensed tannins were blended directly into the food mixture (8 g/kg diet) |
| Vitamin K <sub>1</sub> (Veda-K <sub>1</sub> , Vedco)                                                          | 0.2-2.2 mg/kg IM q4-8h until stable, then q24h                                   | Most species, including raptors/rodenticide anticoagulant toxicosis                                                                                                                                                                                                    |

|  |                                                                           |                                                  |
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|  | PO, IM × 14-28                                                            |                                                  |
|  | days <a href="#">399, 437</a><br>2.3 mg/kg SC<br>q12h <a href="#">549</a> | Red-tailed hawks/secondary brodifacoum toxicosis |

<sup>a</sup> Cathartics increase gastrointestinal motility and are used to evacuate the gut and prevent absorption of toxins.

TABLE 5-10 Psychotropic Agents Used in Birds.<sup>a</sup>

| Agent                                                               | Dosage                                                                                                                    | Species/Comments                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
|---------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Amitriptyline<br>(Flavil, Stuart)                                   | —                                                                                                                         | Tricyclic antidepressant; inhibits serotonin reuptake; antihistamine                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
|                                                                     | 1-5 mg/kg<br>PO q12-<br>24h <sup>702</sup>                                                                                | Most species/feather picking; obsessive compulsive disorders;<br>phobias <sup>840</sup>                                                                                                                                                                                                                                                                                                                                                                                                                                              |
|                                                                     | 2 mg/kg PO<br>q24h <sup>224</sup>                                                                                         | Psittacines/minimum of 30 days                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
| Buspirone HCl<br>(Buspar, Bristol-<br>Myers Squibb)                 | 0.5 mg/kg PO<br>q12h <sup>404</sup>                                                                                       | Anxiolytic; used to control behavior interpreted as paradoxical<br>anxiety caused by clomipramine                                                                                                                                                                                                                                                                                                                                                                                                                                    |
| Carbamazepine<br>(Tegretol,<br>Novartis)                            | 3-10 mg/kg<br>PO q24h <sup>641</sup>                                                                                      | Most species/anticonvulsant, analgesic; may cause bone marrow<br>suppression (including aplastic anemia and agranulocytosis) and<br>hepatotoxicity; combination with chlorpromazine or haloperidol<br>recommended for initial treatment during the first 2 wk <sup>692</sup>                                                                                                                                                                                                                                                         |
|                                                                     | 166 mg/L<br>drinking<br>water <sup>692</sup>                                                                              |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| Chlorpromazine                                                      | —                                                                                                                         | Phenothiazine; dopamine antagonist <sup>840</sup> used in some cases of<br>feather picking; correct underlying problems and discontinue within<br>30 days; <sup>840</sup> efficacy diminishes in 14-30 days when given PO; <sup>692</sup><br>may cause ataxia, regurgitation, drowsiness <sup>696</sup>                                                                                                                                                                                                                              |
|                                                                     | Mix 1 mL<br>stock<br>solution/120<br>mL drinking<br>water or 0.2-<br>1 mL/kg<br>stock PO<br>q12-24h<br>prn <sup>692</sup> | Most species/stock solution: crush five 25 mg tablets and mix with<br>31 mL simple syrup; start at low dose initially; mild sedation                                                                                                                                                                                                                                                                                                                                                                                                 |
|                                                                     | 0.1-0.2<br>mg/kg IM<br>once <sup>692</sup>                                                                                | Cockatoos, ringneck parakeets/use with carbamazepine following<br>removal of Elizabethan collar; mild sedation and decreases<br>obsessive behaviors                                                                                                                                                                                                                                                                                                                                                                                  |
| Clomipramine<br>(Anafranil,<br>Novartis;<br>Clomicalm,<br>Novartis) | —                                                                                                                         | Tricyclic antidepressant; antihistamine; may cause regurgitation,<br>drowsiness; adverse effects in mammals include cardiac conduction<br>abnormalities, tachyarrhythmias, postural hypotension, dry mucous<br>membranes, urinary retention, constipation, and lowering of the<br>seizure threshold; <sup>404</sup> anecdotal reports of death in birds possibly<br>associated with pre-existing arrhythmias; <sup>287</sup> wait 2-3 wk before<br>adjusting dose; <sup>79</sup> reports of illness, extrapyramidal signs, and death |

|                                 |                                                                |                                                                                                                                                                                               |
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|                                 |                                                                | reported in macaws <sup>764</sup>                                                                                                                                                             |
|                                 | 0.5-1 mg/kg<br>PO q12-<br>24h <sup>287,811,812</sup>           | Psittacines/feather picking; self-mutilation; start with low dose and gradually increase over 4-5 days                                                                                        |
|                                 | 1 mg/kg PO<br>q24h or<br>divided q12h<br>× 6 wk <sup>642</sup> | Psittacines/feather picking; obsessive compulsive disorders; phobias; <sup>840</sup> occasional regurgitation and drowsiness observed; 2 of 11 birds decreased feather picking <sup>642</sup> |
|                                 | 1-2 mg/kg<br>PO q24h <sup>380</sup>                            | Psittacines/begin with 1 mg/kg and increase if needed                                                                                                                                         |
|                                 | 3 mg/kg PO<br>q12h <sup>732,856</sup>                          | Cockatoos/no appreciable deleterious side effects; no significant differences between baseline and post-treatment bloodwork or body weight <sup>856</sup>                                     |
|                                 | 4-8 mg/kg<br>PO q12h <sup>404</sup>                            | African grey parrots/behavior interpreted as paradoxical anxiety; combine with anxiolytic therapy (buspirone)                                                                                 |
|                                 | 3-5 mg/kg<br>PO q12-<br>24h <sup>732</sup>                     | Psittacines/compulsive feather picking or impulse-control disorder; anxiety                                                                                                                   |
| Delmadinone<br>(Tardak, Pfizer) | 1 mg/kg IM<br>once <sup>445</sup>                              | Psittacines/sexual behavior problems; not available in the United States                                                                                                                      |
| Diazepam                        | —                                                              | Benzodiazepine sedative; anxiolytic/stress-associated feather picking; <sup>840</sup> useful as sole agent or in combination with phenobarbital for seizure control                           |
|                                 | 0.25-0.5<br>mg/kg IM,<br>IV q24h × 2-<br>3 days <sup>776</sup> | Raptors/appetite stimulant                                                                                                                                                                    |
|                                 | 0.5 mg/kg<br>PO <sup>283,513</sup>                             | Passerines/calm fractious species while improving acceptance to a novel captive diet; oral solution (1 mg/mL; Roxane Laboratories) worked best                                                |
|                                 | 0.5-0.6<br>mg/kg<br>IM <sup>47,287</sup>                       | Most species/facilitates acceptance of Elizabethan collar, especially in lovebirds                                                                                                            |
|                                 | 0.5-1 mg/kg<br>IM, IV q8-<br>12h <sup>511,696</sup>            | Most species/control of seizures                                                                                                                                                              |
|                                 | 0.5-1.5<br>mg/kg PO,<br>IM, IV<br>q8h <sup>147</sup>           | Psittacines/control of seizures                                                                                                                                                               |
|                                 | 2.5-4 mg/kg                                                    | Psittacines/sedation                                                                                                                                                                          |



|                                 |                                                                |                                                                                                                                                                                                                                              |
|---------------------------------|----------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                                 | PO 2-6 mg/kg<br>10-20 mg/L<br>drinking<br>water <sup>292</sup> | Most species                                                                                                                                                                                                                                 |
| Diphenhydramine                 | —                                                              | Antihistamine; mild hypnotic effects; suspected allergic feather picking                                                                                                                                                                     |
|                                 | 2-4 mg/kg<br>PO q12h <sup>292</sup>                            | Most species                                                                                                                                                                                                                                 |
|                                 | 2 mg/L<br>drinking<br>water <sup>840</sup>                     | Most species                                                                                                                                                                                                                                 |
| Doxepin                         | —                                                              | Tricyclic antidepressant; antihistamine; dose may be increased at 14-day intervals; <sup>147</sup> may cause sedation <sup>840</sup>                                                                                                         |
|                                 | 0.5-1 mg/kg<br>PO<br>q12h <sup>292,387</sup>                   | Most species/feather picking                                                                                                                                                                                                                 |
|                                 | 1-2 mg/kg<br>PO q12h <sup>730</sup>                            | Psittacines/anxiety; pruritis                                                                                                                                                                                                                |
| Fluoxetine<br>(Prozac, Dista)   | —                                                              | Selective serotonin reuptake inhibitor; antidepressant; adjunctive treatment for depression-induced feather picking <sup>840</sup>                                                                                                           |
|                                 | 0.4 mg/kg PO<br>q24h <sup>64</sup>                             | Psittacines/feather picking                                                                                                                                                                                                                  |
|                                 | 0.4-4 mg/kg<br>PO q24h <sup>730</sup>                          | Psittacines/compulsive feather picking                                                                                                                                                                                                       |
|                                 | 1 mg/kg PO<br>q24h <sup>840</sup>                              | Psittacines                                                                                                                                                                                                                                  |
|                                 | 2-3 mg/kg<br>PO q12-<br>24h <sup>523,685</sup>                 | Most species, including psittacines                                                                                                                                                                                                          |
| Haloperidol<br>(Haldol, McNeil) | —                                                              | Butyrophenone dopamine antagonist tranquilizer; may work best with self-mutilators; <sup>366,453</sup> may cause anorexia or depression; <sup>840</sup> reports of illness, extrapyramidal signs and death reported in macaws <sup>764</sup> |
|                                 | 0.1 mg/kg PO<br>q12-24h <sup>381</sup>                         | Macaws/aggression; feather picking; used in conjunction with lorazepam                                                                                                                                                                       |
|                                 | 0.1-0.15<br>mg/kg PO<br>q12-<br>24h <sup>287,453,696</sup>     | Birds weighing >1 kg                                                                                                                                                                                                                         |
|                                 | 0.1-0.4<br>mg/kg PO                                            | Psittacines/dose may be increased in increments of 0.01 mg/kg if no response is seen in 5-7 days and no adverse effects are observed                                                                                                         |

|                                            |                                                                  |                                                                                                                                                                                                                                                     |
|--------------------------------------------|------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                                            | 0.2 mg/kg PO<br>q12h <sup>380,445</sup>                          | Most species <1 kg                                                                                                                                                                                                                                  |
|                                            | 0.2-0.9<br>mg/kg PO<br>q24h <sup>730</sup>                       | Most species/stereotypic preening behavior                                                                                                                                                                                                          |
|                                            | 1-2 mg/kg<br>IM q14-<br>21d <sup>292,812</sup>                   | Most species, including psittacines                                                                                                                                                                                                                 |
|                                            | 6.4 mg/L<br>drinking<br>water × 7<br>mo <sup>366</sup>           | African grey parrots/feather picking                                                                                                                                                                                                                |
| Hydroxyzine<br>(Atarax, Roerig)            | —                                                                | Antihistamine with mild sedative effects                                                                                                                                                                                                            |
|                                            | 2 mg/kg PO<br>q12h <sup>730</sup>                                | Most species/pruritis                                                                                                                                                                                                                               |
|                                            | 2-2.2 mg/kg<br>PO q8h <sup>292,436</sup>                         | Most species/feather picking                                                                                                                                                                                                                        |
|                                            | 30-40 mg/L<br>drinking<br>water <sup>79,292</sup>                | Most species                                                                                                                                                                                                                                        |
| Lorazepam<br>(Ativan, Wyeth<br>Ayerst)     | —                                                                | Benzodiazepine with anxiolytic and sedative effects                                                                                                                                                                                                 |
|                                            | 0.1 mg/kg PO<br>q12h <sup>381</sup>                              | Macaws/aggression; feather picking; use alone or with haloperidol                                                                                                                                                                                   |
| Megestrol acetate<br>(Ovaban,<br>Schering) | —                                                                | Progestin providing nonspecific calming effects; <sup>79</sup> side effects can be severe (diabetic-like); seldom used                                                                                                                              |
|                                            | 2.5 mg/kg PO<br>q24h × 7<br>days then 1-2<br>×/wk <sup>445</sup> | Psittacines/feather picking; reproductively associated behavior problems                                                                                                                                                                            |
| Naloxone HCl<br>(Narcan, DuPont)           | 2 mg/kg<br>IV <sup>380</sup>                                     | Psittacines/opioid antagonist; may be used to determine the response of stereotypic behavior to antagonist therapy; reduction of the behavior should be observed within 20 min                                                                      |
| Naltrexone HCl                             | 1.5 mg/kg PO<br>q8-12h × 1-<br>18 mo <sup>816</sup>              | Most species/opioid antagonist; feather picking; self mutilation; contraindicated in patients with liver disease; may need to increase dosage 2-6 × to be effective; dissolve tablet in 10 mL sterile water; preservative does not go into solution |
| Nortriptyline                              | 16 mg/L<br>drinking                                              | Most species/tricyclic antidepressant; feather picking; seldom used;                                                                                                                                                                                |

|                                        |                                              |                                                                                                                                                                                                                                                                                                                                                                                                                                         |
|----------------------------------------|----------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| (Pamelor, Sandoz)                      | water (2 mg/120 mL) <sup>292</sup>           | decrease dose or discontinue if hyperactivity develops; taper dose to discontinue <sup>812</sup>                                                                                                                                                                                                                                                                                                                                        |
| Paroxetine (Paxil, SmithKline Beecham) | 1-2 mg/kg PO q24h <sup>412</sup>             | Macaw, ibis/selective serotonin reuptake inhibitor; feather picking; self-mutilation; generally requires long-term therapy                                                                                                                                                                                                                                                                                                              |
|                                        | 3 mg/kg PO q24h <sup>412</sup>               | Pigeons                                                                                                                                                                                                                                                                                                                                                                                                                                 |
| Phenobarbital sodium                   | —                                            | Barbiturate anticonvulsant; mild sedative effect; long-term seizure management; adjust dosage based on blood levels; may cause deep sedation and inability to perch <sup>702</sup>                                                                                                                                                                                                                                                      |
|                                        | 1-5 mg/kg IV bolus <sup>30</sup>             | Most species/status epilepticus; begin at low end of dosage range and increase for refractory seizures                                                                                                                                                                                                                                                                                                                                  |
|                                        | 1-7 mg/kg PO q8-12h <sup>292</sup>           | Most species/feather picking; mild sedative effect                                                                                                                                                                                                                                                                                                                                                                                      |
|                                        | 2-7 mg/kg PO q12h <sup>59,287,393</sup>      | Most species, including Amazon parrots/seizures; self-mutilation                                                                                                                                                                                                                                                                                                                                                                        |
|                                        | 50-80 mg/L drinking water <sup>632,862</sup> | Most species, including Amazon parrots/idiopathic epilepsy                                                                                                                                                                                                                                                                                                                                                                              |
| Potassium bromide                      | —                                            | Long-term seizure management; use as sole agent or in conjunction with phenobarbital; monitor blood levels which may take up to 90 days to establish steady state; <sup>867</sup> not available in approved dosage forms in North America; may be obtained from chemical companies or compounding pharmacies; for a concentration of 250 mg/mL, add distilled water as needed to 25 g of potassium bromide for a final volume of 100 mL |
|                                        | 25 mg/kg PO q24h <sup>146</sup>              | Most species                                                                                                                                                                                                                                                                                                                                                                                                                            |
|                                        | 50-80 mg/kg PO q24h <sup>867</sup>           | Pigeons                                                                                                                                                                                                                                                                                                                                                                                                                                 |
|                                        | 75 mg/kg PO <sup>147</sup>                   | Psittacines                                                                                                                                                                                                                                                                                                                                                                                                                             |
|                                        | 80 mg/kg PO q24h <sup>82</sup>               | Umbrella cockatoo/serum drug levels ranged from 1.7-2.2 mg/mL                                                                                                                                                                                                                                                                                                                                                                           |

<sup>a</sup> The use of psychotropic agents in birds is controversial because safety, efficacy, and pharmacologic effects are poorly documented; anxiolytics or tricyclic antidepressants may be useful for stereotypic behaviors or mutilation; selective serotonin reuptake inhibitors may prove helpful for explosive behaviors;<sup>589</sup>

consider metabolic scaling when calculating dosages; these treatments should be used as components of a structured behavior-change strategy.

TABLE 5-11 Nutritional/Mineral Support Used in Birds.

| Agent                       | Dosage                                                            | Species/Comments                                                              |
|-----------------------------|-------------------------------------------------------------------|-------------------------------------------------------------------------------|
| Biotin                      | 0.05 mg/kg PO q24h × 30-60 days <sup><a href="#">63,702</a></sup> | Raptors/beak and nail regrowth                                                |
| Brewer’s yeast              | 30 mg/bird in feed <sup><a href="#">63</a></sup>                  | Pigeons/brittle plumage; use daily during molt                                |
| Calcium                     | —                                                                 | Recommended dietary levels <sup><a href="#">a</a></sup>                       |
|                             | 3-10 mg/kg feed (0.3-1%) <sup><a href="#">390</a></sup>           | Laying parrots                                                                |
|                             | 4-8 mg/kg feed (0.4-0.8%) <sup><a href="#">562</a></sup>          | Growing Muscovy ducks                                                         |
|                             | 8 mg/kg feed (0.8%) <sup><a href="#">562</a></sup>                | Growing Japanese quail                                                        |
|                             | 8-10 mg/kg feed (0.8-1%) <sup><a href="#">562</a></sup>           | Growing chickens                                                              |
|                             | 18.8-32.5 mg/kg feed (1.88-3.25%) <sup><a href="#">562</a></sup>  | Laying chickens/3.25% recommended for hens that lay eggs daily                |
|                             | 22.5 mg/kg feed (2.25%) <sup><a href="#">562</a></sup>            | Laying turkeys                                                                |
| Calcium borogluconate (10%) | 50-100 mg/kg IM, IV <sup><a href="#">64</a></sup>                 | Psittacines/20% solution                                                      |
|                             | 100-500 mg/kg SC, IV (slow) once <sup><a href="#">63</a></sup>    | Raptors/hypocalcemia                                                          |
|                             | 300 mg/kg IV <sup><a href="#">259</a></sup>                       | Goshawks                                                                      |
| Calcium chloride            | 150-200 mg/kg IM, IV (slow) q8h <sup><a href="#">801</a></sup>    | Hypocalcemia; seldom used                                                     |
| Calcium glubionate          | —                                                                 | Most species/hypocalcemia, calcium supplementation                            |
|                             | 23 mg/kg PO q24h <sup><a href="#">402</a></sup>                   | Psittacines (neonates)                                                        |
|                             | 25 mg/kg PO <sup><a href="#">48,363</a></sup>                     | Most species, including raptors                                               |
|                             | 150 mg/kg PO q12h <sup><a href="#">365,812</a></sup>              | Most species                                                                  |
|                             | 750 mg/L drinking water <sup><a href="#">365</a></sup>            | Most species                                                                  |
| Calcium gluconate (10%)     | —                                                                 | Hypocalcemia; dilute 1:1 with saline or sterile water for IM or IV injections |
|                             | 5-10 mg/kg IV slowly to effect <sup><a href="#">812</a></sup>     | Psittacines/hypocalcemic tetany                                               |

|                                                                   |                                                                                                                                                 |                                                                                                                                                                                                                                                                                                                                                        |
|-------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                                                                   | 5-10 mg/kg SC, IM q12h prn <a href="#">702,812</a>                                                                                              | Psittacines                                                                                                                                                                                                                                                                                                                                            |
|                                                                   | 10-100 mg/kg IM <a href="#">390</a>                                                                                                             | Psittacines/acute presentation of hypocalcemia                                                                                                                                                                                                                                                                                                         |
|                                                                   | 25-50 mg/kg SC, IV (slow) <a href="#">702</a>                                                                                                   | Pigeons                                                                                                                                                                                                                                                                                                                                                |
|                                                                   | 50-100 mg/kg IM (diluted), IV (slow) <a href="#">363,365,399,671,693,702</a>                                                                    | Most species, including psittacines, pigeons, raptors                                                                                                                                                                                                                                                                                                  |
|                                                                   | 100-500 mg/kg SC, IV (slow) once <a href="#">702</a>                                                                                            | Raptors/hypocalcemia                                                                                                                                                                                                                                                                                                                                   |
|                                                                   | 1 mL/30 mL (3300 mg/L) drinking water <a href="#">812</a>                                                                                       | Psittacines/calcium supplementation                                                                                                                                                                                                                                                                                                                    |
| Calcium lactate/calcium glycerophosphate (Calphosan, Glenwood)    | 5-10 mg/kg IM q7d prn <a href="#">48,363,365,696</a>                                                                                            | Most species, including raptors/hypocalcemia                                                                                                                                                                                                                                                                                                           |
|                                                                   | 50-100 mg/kg IV (slow bolus) once <a href="#">638</a>                                                                                           | African grey parrots                                                                                                                                                                                                                                                                                                                                   |
| Calcium levulinate                                                | 75-100 mg/kg IM, IV <a href="#">365</a>                                                                                                         | Most species/hypocalcemia                                                                                                                                                                                                                                                                                                                              |
| L-carnitine                                                       | 1000 mg/kg feed <a href="#">185</a>                                                                                                             | Budgerigars/PD; lipomas; average lipoma size decreased significantly                                                                                                                                                                                                                                                                                   |
| Dextrose (50%)                                                    | 50-100 mg/kg IV (slow bolus) to effect <a href="#">696,812</a>                                                                                  | Psittacines/hypoglycemia; can dilute with fluids                                                                                                                                                                                                                                                                                                       |
|                                                                   | 500-1000 mg/kg IV (slow bolus) <a href="#">133,634</a>                                                                                          | Hypoglycemia; can dilute with fluids                                                                                                                                                                                                                                                                                                                   |
| Diatrizoate meglumine sodium (37% iodine) (Renografin-76, Solvay) | —                                                                                                                                               | Parenteral treatment of goiter is generally reserved for emergency situations                                                                                                                                                                                                                                                                          |
|                                                                   | 122 mg/kg IM <a href="#">534,672</a>                                                                                                            | Budgerigars/thyroid hyperplasia                                                                                                                                                                                                                                                                                                                        |
| Essential fatty acids                                             | 0.5 mL/kg PO q24h × 50 days or indefinitely <a href="#">702</a>                                                                                 | Raptors/pruritic dermatitis (atopy)                                                                                                                                                                                                                                                                                                                    |
| Fatty acids (omega-3, omega-6)                                    | 0.1-0.2 mL/kg of flaxseed oil to corn oil mixed at a ratio of 1:4 PO or added to food; ratio of omega-6:omega-3 is 4-5:1 <a href="#">45,209</a> | Psittacines, pigeons/glomerular disease; used to reduce thromboxane A <sub>2</sub> synthesis in platelets and glomerular cells; adjunct therapy for arthritis, feather-picking, mutilators, and neoplasia; 2-4 wk of therapy are required to recognize effects; may increase dietary vitamin E requirements; consider supplementation with chronic use |
|                                                                   | 0.11 mL/kg q24h in a 5:1 ratio of omega-6:omega-                                                                                                | Psittacines/glomerulonephritis, pancreatitis                                                                                                                                                                                                                                                                                                           |

|                                                  |                                                                                                    |                                                                                                                                                                                                              |
|--------------------------------------------------|----------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                                                  | 3 <sup><a href="#">190</a></sup>                                                                   |                                                                                                                                                                                                              |
| Folic acid                                       | 50-100 µg IM <sup><a href="#">35</a></sup>                                                         | Poultry chicks/treatment of deficiency; anemia improved in 4 days                                                                                                                                            |
| Hemicellulose (Metamucil, Searle)                | —                                                                                                  | For bulk in diet; facilitates defecation in bowel deficit disorders and other conditions                                                                                                                     |
|                                                  | Small amount on food daily <sup><a href="#">689</a></sup>                                          | Most species                                                                                                                                                                                                 |
|                                                  | 0.5 tsp/60 mL hand-feeding formula or baby food gruel <sup><a href="#">437</a></sup>               | Psittacines/bulk diet to delay absorbtion of an ingested toxin                                                                                                                                               |
|                                                  | 1 Tbs/60 mL water q24h <sup><a href="#">810</a></sup>                                              | Ostrich chicks/impaction                                                                                                                                                                                     |
| Iodine (Lugol's iodine)                          | 0.2 mL/L drinking water daily <sup><a href="#">365</a></sup>                                       | Most species/thyroid hyperplasia                                                                                                                                                                             |
|                                                  | 2 parts iodine + 28 parts water; 3 drops into 100 mL drinking water <sup><a href="#">702</a></sup> | Budgerigars/thyroid hyperplasia                                                                                                                                                                              |
| Iodine (sodium iodide 20%)                       | —                                                                                                  | Parenteral treatment of goiter is generally reserved for emergency situations or initial treatment of severe thyroid dysplasia; continue with oral therapy when improvement is noted                         |
|                                                  | 2 mg (0.01 mL)/bird IM prn <sup><a href="#">48</a></sup>                                           | Budgerigars                                                                                                                                                                                                  |
|                                                  | 60 mg (0.3 mL)/kg IM <sup><a href="#">365</a></sup>                                                | Most species/thyroid hyperplasia                                                                                                                                                                             |
| Iron                                             | 20-40 mg/kg feed <sup><a href="#">159,161</a></sup>                                                | Toucans/levels recommended for a low-iron diet                                                                                                                                                               |
| Iron dextran                                     | 10 mg/kg IM, repeat in 7-10 days prn <sup><a href="#">63,671</a></sup>                             | Most species, including raptors, waterfowl/iron deficiency anemia; use cautiously in species in which iron storage disease is common (e.g., toucans, mynahs, starlings, birds of paradise, other passerines) |
| Lactobacillus (Bene-Bac, Pet-Ag)                 | 1 pinch/day/bird <sup><a href="#">812</a></sup>                                                    | Psittacines/stimulation of normal gastrointestinal flora regrowth                                                                                                                                            |
|                                                  | 1 tsp/L hand-feeding formula <sup><a href="#">812</a></sup>                                        | Most species                                                                                                                                                                                                 |
| Niacin (nicotinic acid)                          | 50 mg/kg PO q8h <sup><a href="#">632</a></sup>                                                     | Psittacines/yolk emboli; give with gemfibrozil (30 mg/kg PO)                                                                                                                                                 |
| Pancreatic enzyme powder (Viokase-V Powder, Fort | —                                                                                                  | Most species/exocrine pancreatic insufficiency; maldigestion; mix with food and let stand 30 min <sup><a href="#">812</a></sup>                                                                              |

|                                         |                                                                                        |                                                                                                                                                                                                             |
|-----------------------------------------|----------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Dodge)                                  | 2-5 g/kg <sup><a href="#">812</a></sup>                                                | Most species                                                                                                                                                                                                |
|                                         | ¼ tsp/kg feed <sup><a href="#">16,812</a></sup>                                        | Most species                                                                                                                                                                                                |
|                                         | ¼ tsp/60-120 g lightly oil-coated seed <sup><a href="#">692</a></sup>                  | Most species                                                                                                                                                                                                |
|                                         | ¼ tsp/30-120 mL hand-feeding formula prn <sup><a href="#">575</a></sup>                | Psittacine neonates                                                                                                                                                                                         |
| Phytonadione                            | —                                                                                      | See vitamin K <sub>1</sub>                                                                                                                                                                                  |
| Selenium (Seletoc, Schering)            | 0.05-0.1 mg Se/kg IM q14d <sup><a href="#">671</a></sup>                               | Most species/neuromuscular diseases (capture myopathy, white muscle disease, some cardiomyopathies); may be useful in some cockatiels with jaw, eyelid, and tongue paralysis <sup><a href="#">671</a></sup> |
|                                         | 0.06 mg Se/kg IM q3-14d <sup><a href="#">365</a></sup>                                 |                                                                                                                                                                                                             |
| Sodium chloride (buffered salt tablet)  | 450 mg PO daily <sup><a href="#">266</a></sup>                                         | Penguins/prevents atrophy of salt gland                                                                                                                                                                     |
| Vitamin A (Aquasol A Parenteral, Astra) | —                                                                                      | 3000 µg/kg dieting vitamin A after 269 days induced increased plasma retinol, splenic hemosiderosis and altered vocalization patterns in cockatiels <sup><a href="#">431</a></sup>                          |
|                                         | 200 U/kg IM <sup><a href="#">396</a></sup>                                             | Raptor juveniles/supplemental therapy for pox infection                                                                                                                                                     |
|                                         | 2000 U/kg PO, IM <sup><a href="#">37</a></sup>                                         | Psittacines/adjunctive therapy for pox infection                                                                                                                                                            |
|                                         | 5000 U/kg IM q24h × 14 days, then 250-1000 U/kg q24h PO <sup><a href="#">147</a></sup> | Psittacines/adjunctive therapy for respiratory or epithelial disease                                                                                                                                        |
|                                         | 20,000 U/kg IM <sup><a href="#">801</a></sup>                                          | Most species/hypovitaminosis A; maximum dose; improves skin healing                                                                                                                                         |
|                                         | 33,000 U/kg (10,000 U/300 g) IM q7d <sup><a href="#">365</a></sup>                     | Most species/hypovitaminosis A                                                                                                                                                                              |
|                                         | 50,000 U/kg IM q7d <sup><a href="#">402</a></sup>                                      | Psittacine neonates                                                                                                                                                                                         |
|                                         | 1 mL/135 kg IM <sup><a href="#">2</a></sup>                                            | Ostriches/hypovitaminosis A                                                                                                                                                                                 |
| Vitamin B <sub>1</sub> (thiamine)       | —                                                                                      | Thiamine deficiency; requirements may be higher if thiaminase is present in diet <sup><a href="#">b</a></sup>                                                                                               |
|                                         | 1-2 mg/kg PO q24h <sup><a href="#">672</a></sup>                                       | Raptors, penguins, cranes/daily supplement                                                                                                                                                                  |
|                                         | 1-2 mg/kg IM q24h <sup><a href="#">363,604,671</a></sup>                               | Vultures, raptors, cranes, penguins/CNS signs                                                                                                                                                               |
|                                         | 1-3 mg/kg IM q7d <sup><a href="#">399,671</a></sup>                                    | Most species, including raptors                                                                                                                                                                             |
|                                         | 1-50 mg/kg PO q24h × 7 days or indefinitely <sup><a href="#">702</a></sup>             | Raptors                                                                                                                                                                                                     |
|                                         |                                                                                        |                                                                                                                                                                                                             |



|                                                                        |                                                                    |                                                                                                                                                  |
|------------------------------------------------------------------------|--------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------|
|                                                                        | 2 mg/kg IM <sup><a href="#">810</a></sup>                          | Ratites/curly toe paralysis                                                                                                                      |
|                                                                        | 3-30 mg/kg IM q7d <sup><a href="#">363</a></sup>                   | Raptors/stimulates appetite, hematopoiesis; neuromuscular disease; liver disease; supportive therapy; adjunct to sulfa therapy                   |
|                                                                        | 1-2 mg/kg feed <sup><a href="#">604</a></sup>                      | Vultures                                                                                                                                         |
|                                                                        | 25-30 mg/kg fish (wet basis) <sup><a href="#">61</a></sup>         | Piscivorous species/recommended level of supplementation                                                                                         |
|                                                                        | 30 mg/kg feed (as fed basis) q48h <sup><a href="#">363</a></sup>   | Raptors/supplement for piscivorous species fed frozen fish                                                                                       |
|                                                                        | 2850 mg/L drinking water q7d <sup><a href="#">702</a></sup>        | Pigeons                                                                                                                                          |
| Vitamin B <sub>12</sub> (cyanocobalamin)                               | 0.25-0.5 mg/kg IM q7d <sup><a href="#">363,671,702</a></sup>       | Most species, including psittacines, raptors/anemia                                                                                              |
|                                                                        | 2-5 mg/bird SC <sup><a href="#">808</a></sup>                      | Pigeons/vitamin B <sub>12</sub> deficiency                                                                                                       |
| Vitamin B complex                                                      | —                                                                  | Usually dosed based on thiamine (see vitamin B <sub>1</sub> )                                                                                    |
| Vitamin C (ascorbic acid)                                              | 20-50 mg/kg IM q1-7d <sup><a href="#">396,397,672</a></sup>        | Most species, including raptors/nutritional support; supplemental therapy for pox infection                                                      |
|                                                                        | 150 mg/kg PO q24h <sup><a href="#">314</a></sup>                   | Willow ptarmigan chicks/PD; supplemental daily requirements over 265 mg/kg diet                                                                  |
| Vitamin D <sub>3</sub> (Vital E-A + D, Schering)                       | 3300 U/kg (1000 U/300 g) IM q7d prn <sup><a href="#">365</a></sup> | Most species/hypovitaminosis D <sub>3</sub> ; hypervitaminosis D may occur with excessive use                                                    |
|                                                                        | 6600 U/kg IM once <sup><a href="#">862</a></sup>                   | Most species                                                                                                                                     |
|                                                                        | 11-30 min of direct sunlight/day <sup><a href="#">391</a></sup>    | Chickens/sufficient for endogenous synthesis of vitamin D                                                                                        |
| Vitamin E (Vitamin E20, Horse Health Products; Bo-SE, Schering Plough) | —                                                                  | 1 mg d α-tocopherol acetate = 1.36 U; 1 mg dL α-tocopherol acetate = 1 U; injectable vitamin E has lower efficacy <sup><a href="#">497</a></sup> |
|                                                                        | 0.06 mg/kg IM q7d <sup><a href="#">702</a></sup>                   | Psittacines/hypovitaminosis E                                                                                                                    |
|                                                                        | 0.06 mg/kg IM <sup><a href="#">810</a></sup>                       | Ratites/prevention or treatment of capture myopathy                                                                                              |
|                                                                        | 15 mg/kg PO once <sup><a href="#">497</a></sup>                    | Raptors/PD; administer without food                                                                                                              |
|                                                                        | 70 mg/kg IM q24h for up to 5 days <sup><a href="#">874</a></sup>   | Pelicans/hypovitaminosis E; steatitis                                                                                                            |
|                                                                        | 200-300 mg/kg IM <sup><a href="#">511</a></sup>                    | Ostrich chicks                                                                                                                                   |
|                                                                        | 200-400 mg/bird PO q24h <sup><a href="#">16</a></sup>              | Great blue herons                                                                                                                                |
|                                                                        | 73.5 mg/kg fish (wet basis) <sup><a href="#">874</a></sup>         | Pelicans/supplementation                                                                                                                         |



|                                                                                                |                                                                                         |                                                                                                                              |
|------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------|
|                                                                                                | 100 mg/kg fish (wet basis) <a href="#">61,874</a>                                       | Piscivorous species/recommended level of supplementation                                                                     |
|                                                                                                | 4400-8800 mg/kg feed <a href="#">16</a>                                                 | Ostrich chicks/hypovitaminosis E                                                                                             |
| Vitamin E/ $\gamma$ -linolenic acid (2%), linoleic acid (71%) (Derm Caps, DVM Pharmaceuticals) | 0.1 mL/kg PO q24h <a href="#">387,534,672</a>                                           | Most species/feather picking; use liquid from gel caps                                                                       |
|                                                                                                | 4000 mg linolenic acid/kg feed <a href="#">544</a>                                      | Japanese quail/PD; reduces essential fatty acid deficient hepatic lipidosi                                                   |
| Vitamin K <sub>1</sub> (phytonadione)                                                          | 0.025-2.5 mg/kg IM q12h <a href="#">301,862</a>                                         | Most species                                                                                                                 |
|                                                                                                | 0.2-2.2 mg/kg IM q4-8h until stable, then q24h $\times$ 14 days <a href="#">399,437</a> | Most species, including raptors/rodenticide toxicity                                                                         |
|                                                                                                | 2.5 mg/kg IM q24h until hemostasis, then q7d prn <a href="#">692</a>                    | Psittacines/vitamin K responsive disorders; hematochezia; coagulopathy                                                       |
|                                                                                                | 5 mg/kg IM q24h for several days <a href="#">70,810</a>                                 | Ratites/coagulopathy                                                                                                         |
|                                                                                                | 10-12.5 mg/kg SC q12h $\times$ 4 days <a href="#">874</a>                               | Pelicans/coagulopathy                                                                                                        |
|                                                                                                | 10-20 mg/kg IM q12-24h <a href="#">16</a>                                               | Psittacines                                                                                                                  |
|                                                                                                | 0.1 mg/kg feed <a href="#">386</a>                                                      | Turkeys/PD; as effective as 1-2 mg/kg in reducing plasma prothrombin time                                                    |
|                                                                                                | 5 mg/kg feed <a href="#">692</a>                                                        | Budgerigars/vitamin K responsive bleeding disorders; mix contents of gel cap into small grain seed mix and coat seed lightly |

<sup>a</sup> Grains and seeds commonly fed to parrots contain calcium levels of approximately 0.02-0.1% DM.

<sup>b</sup> Food items known to contain appreciable amounts of thiaminase include clams, herring, smelt, and mackerel.[61](#)

TABLE 5-12 Ophthalmologic Agents Used in Birds.[a](#)

| Agent | Dosage                   | Species/Comments                        |
|-------|--------------------------|-----------------------------------------|
|       | 125 $\mu$ g/5 mL sterile | Ducks (ornamental)/candidiasis of third |

|                                                     |                                                                                                           |                                                                                                                                                                       |
|-----------------------------------------------------|-----------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Amphotericin B                                      | water subconjunctival <sup>8</sup>                                                                        | eyelid                                                                                                                                                                |
| Amphotericin B ointment (4%)<br>(formulated)        | Topical q24h <sup>8</sup>                                                                                 | Ducks (ornamental)/candidiasis of third eyelid; administered in conjunction with systemic antifungal therapy                                                          |
| Atropine (0.4-0.5%)                                 | 0.6 mg/bird topical <sup>639</sup>                                                                        | Cockatoos/PD; partial mydriasis; some birds have iridal smooth muscle; may cause ocular irritation, weakness, shallow breathing; dilute with 0.9% saline <sup>a</sup> |
|                                                     | Topical <sup>89</sup>                                                                                     | Ratites/partial mydriasis; use in combination with curariform drugs; some ratites have iridal smooth muscle <sup>a</sup>                                              |
| Bacitracin/neomycin/polymyxin B sulfate             | Small bead topical <sup>692</sup>                                                                         | Most species/antibiotic; corneal ulcers, conjunctivitis; excessive amounts will cause eye wiping and soiled plumage                                                   |
| Chloramphenicol ophthalmic drops                    | 1 drop topical q6-8h <sup>387</sup>                                                                       | Pigeons/antibiotic                                                                                                                                                    |
| Ciprofloxacin HCl (0.3%)<br>(Ciloxan, Alcon)        | 1 drop topical q4-8h <sup>8</sup>                                                                         | Most species/antibiotic; corneal ulcers, conjunctivitis (e.g., <i>Chlamydophila</i> , <i>Mycoplasma</i> )                                                             |
|                                                     | One drop topical q12h; use in conjunction with Tylosin 1 mg/mL drinking water × 21-77 days <sup>512</sup> | House finches/ <i>Mycoplasma gallisepticum</i> conjunctivitis                                                                                                         |
| Demercarium bromide (0.125%) (Humorsol, Merck)      | 1 drop topical <sup>8</sup>                                                                               | Most species/topical anesthetic; allows removal of <i>Thelazia</i>                                                                                                    |
| Dexamethasone (0.1%) ophthalmic drops               | 1 drop topical q4-8h <sup>363</sup>                                                                       | Raptors/traumatic anterior uveitis without corneal ulceration                                                                                                         |
| Edetate disodium ophthalmic drops                   | 1 drop several times daily <sup>614</sup>                                                                 | Most species/used to treat calcific keratopathy                                                                                                                       |
| Fumagillin (Fumidil B; Mid-Continent Agrimarketing) | 1 drop topical q2h <sup>108</sup>                                                                         | Amazon parrots/fungal and microsporidial keratoconjunctivitis                                                                                                         |
|                                                     | 0.114 mg/mL drops q2-3h until 1 wk postclinical signs <sup>748</sup>                                      | Lovebirds/ <i>Encephalitozoon hellem</i> conjunctivitis; used in combination with albendazole                                                                         |
|                                                     | 60 mg in sterile water topical <sup>748</sup>                                                             | Most species/filter solution to remove bacteria before applying                                                                                                       |
| Gentamicin sulfate                                  | 1 drop topical q4-8h <sup>692</sup>                                                                       | Most species/antibiotic; corneal ulcers; causes irritation                                                                                                            |
| Isoflurane                                          | 1-2% maintenance <sup>617</sup>                                                                           | Most species/mydriasis <sup>a</sup>                                                                                                                                   |
|                                                     | 0.005-0.05 mg topical                                                                                     | Chicken/PD; conjunctival oxyspirurid (nematode) infection; no adverse effects                                                                                         |

|                                                                     |                                                                           |                                                                                                                                                          |
|---------------------------------------------------------------------|---------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------|
| Ivermectin                                                          | q24h × 10 days <sup><a href="#">803</a></sup>                             | were seen with topical use                                                                                                                               |
| Ketamine                                                            | 15-20 mg/kg IM <sup><a href="#">172</a></sup>                             | Raptors/mydriasis; will cause sedation; isoflurane anesthesia is more commonly used <sup><a href="#">a</a></sup>                                         |
| Miconazole (Monistat IV, Janssen)                                   | 1 drop topical q2h <sup><a href="#">108</a></sup>                         | Amazon parrots/fungal keratitis                                                                                                                          |
| Miconazole vaginal cream (2%) (Monistat, Ortho-McNeal)              | Topical <sup><a href="#">8</a></sup>                                      | Most species/antifungal                                                                                                                                  |
| Natamycin (Natacyn, Alcon)                                          | 1 drop topical q6h <sup><a href="#">671</a></sup>                         | Most species/antifungal; gradually taper off                                                                                                             |
| Neomycin/polymyxin B/gramicidin                                     | 1 drop topical q2-8h <sup><a href="#">692</a></sup>                       | Most species/antibiotic; corneal ulcers; conjunctivitis                                                                                                  |
| Oxybuprocaine (0.45%)                                               | Topical <sup><a href="#">430</a></sup>                                    | Pigeons, buzzards/topical anesthetic of choice due to reliable effect with minimal side effects                                                          |
| Oxytetracycline/polymyxin B (Terramycin, Pfizer)                    | Small bead topical <sup><a href="#">692</a></sup>                         | Most species/antibiotic; conjunctivitis; excessive amounts will cause eye-wiping and soiled plumage                                                      |
| Phenylephrine (2.5%)                                                | Topical <sup><a href="#">89</a></sup>                                     | Ratites/partial mydriasis; use in combination with curariform drugs; some ratites have iridal smooth muscle <sup><a href="#">a</a></sup>                 |
| Phenylephrine (4-5%)                                                | —                                                                         | 4-5% ophthalmic solution is not available in the United States                                                                                           |
|                                                                     | 6 mg/bird topical <sup><a href="#">639</a></sup>                          | Cockatoos/PD; partial mydriasis; some birds have iridal smooth muscle; may cause ocular irritation, weakness, shallow breathing; dilute with 0.9% saline |
|                                                                     | Topical <sup><a href="#">470</a></sup>                                    | Cormorants/mydriasis; used in combination with vecuronium bromide and atropine                                                                           |
| Pimaricin (Natacyn, Alcon)                                          | 1 drop topical q6h, taper after 14-21 days <sup><a href="#">672</a></sup> | Most species/polyene antifungal                                                                                                                          |
| Prednisolone acetate (1%)                                           | 1 drop topical q4-8h <sup><a href="#">363</a></sup>                       | Raptors/traumatic anterior uveitis without corneal ulceration                                                                                            |
| Proxymetacaine (proparacaine) (0.5%)                                | Topical <sup><a href="#">430</a></sup>                                    | Topical anesthetic                                                                                                                                       |
| Tetracaine (6%)                                                     | Topical <sup><a href="#">430</a></sup>                                    | Topical anesthetic                                                                                                                                       |
| Tissue plasminogen activator (rTPA) (TNKase Tenecteplase, Genetech) | 50 µg via injection <sup><a href="#">429</a></sup>                        | Raptors/hyphema (use paracentesis into the anterior eye chamber); intraocular hemorrhage (use intravitreal injection)                                    |
|                                                                     |                                                                           |                                                                                                                                                          |

|                                                               |                                                                                                                   |                                                                                                                                                                                                                                     |
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| Triamcinolone (Vetalog, Fort Dodge)                           | 0.1-0.25 mL subconjunctival <sup><a href="#">363</a></sup>                                                        | Raptors/traumatic anterior uveitis without corneal ulceration in patients where restraint is a concern                                                                                                                              |
|                                                               | 0.06 mg/kg subconjunctival <sup><a href="#">120</a></sup>                                                         | Raptors (great horned owls)/cataract surgery                                                                                                                                                                                        |
| d-Tubocurarine (Curarin-Asta, Asta-Werke, Bielefeld, Germany) | —                                                                                                                 | Mydriatic agent; <sup><a href="#">a</a></sup> recommended for therapeutic use only; administer into anterior chamber; high risk of intraocular injury; topical application has no effect <sup><a href="#">427</a></sup>             |
|                                                               | 0.01-0.03 mL of 0.3% solution, intracameral <sup><a href="#">89,428,546</a></sup>                                 | Most species, including pigeons, raptors/dilation within 15 min, duration 4-12 hr                                                                                                                                                   |
| Tylosin                                                       | Topical (mix powder 1:10 with sterile water) <sup><a href="#">8</a></sup>                                         | Cockatiels/conjunctivitis; use in conjunction with systemic treatment                                                                                                                                                               |
| Vecuronium bromide (Norcuron, Organon)                        | —                                                                                                                 | Mydriatic agent; may cause respiratory paralysis or shallow breathing, ataxia, death (especially when applied bilaterally); <sup><a href="#">526</a></sup> neostigmine may counteract systemic effects <sup><a href="#">a</a></sup> |
|                                                               | 0.096 mg/bird of 0.08% solution topical <sup><a href="#">639</a></sup>                                            | Cockatoos, blue-fronted Amazon parrots, African grey parrots/PD                                                                                                                                                                     |
|                                                               | 0.18-0.22 mg/kg topical <sup><a href="#">639</a></sup>                                                            | African grey parrots/PD                                                                                                                                                                                                             |
|                                                               | 0.18-0.29 mg/kg topical <sup><a href="#">639</a></sup>                                                            | Cockatoos/PD                                                                                                                                                                                                                        |
|                                                               | 0.24-0.28 mg/kg topical <sup><a href="#">639</a></sup>                                                            | Blue-fronted Amazon parrots/PD                                                                                                                                                                                                      |
|                                                               | 0.96 mg/bird topical <sup><a href="#">639</a></sup>                                                               | Cockatoos/use caution with bilateral application                                                                                                                                                                                    |
|                                                               | 1 drop of 0.4% solution topical <sup><a href="#">851</a></sup>                                                    | Cormorants, loons/dilation at 30-45 min; duration >2 hr                                                                                                                                                                             |
|                                                               | 2 drops of 0.4% solution topical q15min × 3 treatments <sup><a href="#">526</a></sup>                             | Kestrels/PD; maximal effect in 65 ± 12 min                                                                                                                                                                                          |
|                                                               | 0.5% solution topical <sup><a href="#">172,526</a></sup>                                                          | Raptors/duration 1 hr                                                                                                                                                                                                               |
| Vecuronium (V)/nitrous oxide (N)/isoflurane (I)               | (V) 0.2 mg/kg IV + 1:1 ratio of oxygen to 33% (N) at 0.3 L/kg/min + (I) 1-2.4% <sup><a href="#">427,428</a></sup> | Most species/mydriasis and anesthesia; gases are administered via air sac cannulation; vecuronium effective up to 256 min in pigeons <sup><a href="#">a</a></sup>                                                                   |

<sup>a</sup> Variable amounts of skeletal muscle are present in the avian iris, giving birds voluntary control over pupil dilation. In many avian patients, the pupils are best dilated by restraining the animal in a dark room.

TABLE 5-13 Oncologic Agents Used in Birds.

| Agent                                         | Dosage                                                       | Species/Comments                                                                                                                                                                       |
|-----------------------------------------------|--------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Acemannan (Carravet, Carrington Laboratories) | 1 mg/kg SC q7d × 4 treatments <sup>857</sup>                 | Cockatoos/chemotherapeutic adjunct therapy                                                                                                                                             |
|                                               | 2 mg/kg intralesional q7d × 4 treatments <sup>857</sup>      | Cockatoos/use prior to surgical debulking in fibrosarcoma                                                                                                                              |
| Asparaginase (Elspar, Merck)                  | 400 U/kg IM q7d <sup>269</sup>                               | Cockatoos/lymphosarcoma; premedicate with diphenhydramine                                                                                                                              |
|                                               | 1650 U/kg SC once <sup>700</sup>                             | Great horned owls/sarcoma; associated with severe bone marrow suppression                                                                                                              |
| Carboplatin                                   | 5 mg/kg IV, IO over 3 min <sup>236,495</sup>                 | Sulphur-crested cockatoos (PD), budgerigars/mix with 5% dextrose to 400 mg/L; renal adenocarcinoma (leg paresis showed improvement over 2 mo; mass continued to grow); mix with saline |
|                                               | 5 mg/kg intralesional <sup>857</sup>                         | Amazon parrots/squamous cell carcinoma; mix with sesame oil or plasma at a concentration of 10 mg/mL                                                                                   |
|                                               | 125 mg/m <sup>2</sup> IV (slow bolus) q14-21d <sup>868</sup> | Amazon parrots/bile duct carcinoma; dilute with 5% dextrose <sup>a</sup>                                                                                                               |
| Chlorambucil (Leukeran, GlaxoSmithKline)      | 1 mg/bird PO 2×/wk <sup>566</sup>                            | Pekin ducks/lymphocytic leukemia or lymphosarcoma; responded to treatment initially, but was euthanatized 1 mo after presentation because of respiratory distress and hemorrhages      |
|                                               | 2 mg/kg PO 2×/wk <sup>677</sup>                              | Umbrella cockatoos/cutaneous lymphosarcoma                                                                                                                                             |
| Cisplatin                                     | 1 mg/kg IV over 1 hr <sup>233,235</sup>                      | Cockatoos/PD; may cause nephrotoxicity; administer IV fluids 1 hr before and 2 hr after infusion                                                                                       |
| Cyclophosphamide                              | 200 mg/m <sup>2</sup> IO q7d <sup>269</sup>                  | Cockatoos/lymphosarcoma <sup>a</sup>                                                                                                                                                   |
|                                               | 300 mg/m <sup>2</sup> PO once <sup>700</sup>                 | Great horned owls/sarcoma; <sup>a</sup> dose associated with severe bone marrow suppression                                                                                            |
|                                               | 2 mg/kg IO                                                   |                                                                                                                                                                                        |

|                                                                            |                                                                                         |                                                                                                                                                                         |
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| Diphenhydramine                                                            | once <sup>269</sup>                                                                     | Cockatoos/before chemotherapy                                                                                                                                           |
| Doxorubicin                                                                | 2 mg/kg IV <sup>234</sup>                                                               | Cockatoos/PD; may produce transient inappetence; frequency was not determined                                                                                           |
|                                                                            | 30 mg/m <sup>2</sup> IO q2d <sup>269</sup>                                              | Cockatoos/lymphosarcoma; <sup>a</sup> premedicate with diphenhydramine                                                                                                  |
|                                                                            | 60 mg/m <sup>2</sup> IV q30d <sup>194</sup>                                             | Blue-fronted Amazon parrots/osteosarcoma; <sup>a</sup> premedicate with diphenhydramine 30 min before; dilute with saline and give over 30 min (anesthesia recommended) |
| Hexyl ether pyropheophorbide-a (Photochlor, Roswell Park Cancer Institute) | 0.3 mg/kg IV <sup>781</sup>                                                             | Hornbills/photosensitizing agent; use 24 hr prior to photodynamic therapy                                                                                               |
| Porfimer sodium (Photofrin, QLT PhotoTherapeutics)                         | 3 mg/kg IV <sup>688</sup>                                                               | Cockatiels/photodynamic therapy                                                                                                                                         |
| Prednisone                                                                 | 1.6 mg/kg PO q24h <sup>700</sup>                                                        | Great horned owls/sarcoma                                                                                                                                               |
| Silymarin (milk thistle)                                                   | 100-150 mg/kg PO divided q8-12h <sup>29</sup>                                           | Hepatic antioxidant/protectant; use in patients with liver disease and as ancillary to chemotherapy; use a low-alcohol or alcohol-free liquid formulation               |
| Vincristine sulfate                                                        | 0.1 mg/kg IV q7-14d <sup>677</sup>                                                      | Cockatoos/monitor CBC weekly                                                                                                                                            |
|                                                                            | 0.5 mg/m <sup>2</sup> IV, then 0.75 mg/m <sup>2</sup> q7d × 3 treatments <sup>566</sup> | Ducks/lymphoma; lymphocytic leukemia <sup>a</sup>                                                                                                                       |
|                                                                            | 0.75 mg/m <sup>2</sup> IO q7d × 3 treatments <sup>269</sup>                             | Cockatoos/lymphosarcoma <sup>a</sup>                                                                                                                                    |

0.5 kg = 0.06 m<sup>2</sup>

1 kg = 0.1 m<sup>2</sup>

2 kg = 0.15 m<sup>2</sup>

3 kg = 0.2 m<sup>2</sup>

4 kg = 0.25 m<sup>2</sup>

$$5 \text{ kg} = 0.29 \text{ m}^2$$

$$^a \text{ Body weight (kg)} = \text{surface area (m}^2\text{)}$$

TABLE 5-14 Antimicrobial-Impregnated Polymethylmethacrylate (PMMA) Agents Used in Birds. [a,223,496,782,845](#)

| Agent                                                              | Dosage                                                            | Species/Comments                                                                                                                                                                   |
|--------------------------------------------------------------------|-------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Bone cement (Surgical Simplex P Radiopaque Bone Cement, Howmedica) | —                                                                 | Polymer powder and liquid monomer for use in making antibiotic impregnated beads <a href="#">845</a>                                                                               |
| Amikacin                                                           | 1.25-2.5 g/20 g polymer powder <a href="#">223</a>                | PD/elution of amikacin from PMMA beads was greater when the powdered form was used compared with liquid amikacin                                                                   |
| Cefazolin                                                          | 1-2 g/20 g polymer powder <a href="#">389</a>                     |                                                                                                                                                                                    |
| Cefotaxime                                                         | 2 g/20 g polymer powder <a href="#">389</a>                       | Mix antibiotic powder with bone cement powder, then add liquid for mixing                                                                                                          |
| Ceftazidime                                                        | 2 g/20 g polymer powder <a href="#">389</a>                       | Mix antibiotic powder with bone cement powder, then add liquid for mixing                                                                                                          |
| Ceftiofur (Naxcel, Pfizer)                                         | 2 g/20 g polymer powder <a href="#">223</a>                       | Studies show elution for approximately 7 days only <a href="#">143</a>                                                                                                             |
| Clindamycin                                                        | —                                                                 | PMMA beads with clindamycin had adequate drug levels for more than 90 days <a href="#">496,666</a>                                                                                 |
| Enrofloxacin (Baytril, Bayer)                                      | —                                                                 | Raptors/pododermatitis <a href="#">666</a>                                                                                                                                         |
| Gentamicin                                                         | —                                                                 | Nephrotoxicity is an uncommon but possible side effect of local gentamicin treatment <a href="#">827</a>                                                                           |
|                                                                    | 1 g powder or solution/20 g polymer powder <a href="#">223</a>    | PD/elution concentration remained greater than MIC for common pathogens for 30 days; powder and liquid forms of gentamicin had similar elution rates from PMMA <a href="#">223</a> |
|                                                                    | 1 mL of 50 mg/mL solution/20 g polymer powder <a href="#">666</a> | Raptors/pododermatitis                                                                                                                                                             |
| Gentamicin (Septopal, Merck)                                       | Premade beads <a href="#">629</a>                                 | Commercially available in Europe; not available in the United States                                                                                                               |



|                                                                    |                                                                                                                                          |                                                                                                                                                                                                                                                        |
|--------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Hydroxyapatite cement (BoneSource, Osteogenics)                    |                                                                                                                                          | Polymer powder used as an alternative to bone cement; absorbs into muscle and tissue; osteoconductive in bone; fabricates with water which aids in formulation with liquid antibiotics <sup>223</sup>                                                  |
| Itraconazole                                                       | 16% itraconazole-impregnated PMMA fed as grit stones <sup>769</sup>                                                                      | Indian peafowl/PD; antifungal agent; when used as grit, therapeutic levels achieved in 2 days and decreased over 7 days; beads from capsules mix into PMMA uniformly before hardening; PMMA cut into 1-g size pieces (grit stone size) after hardening |
| Oxytetracycline                                                    | 4.5 mL of 200 mg/mL solution/20 g polymer powder <sup>666</sup>                                                                          | Raptors/pododermatitis                                                                                                                                                                                                                                 |
| (R) Rifampin/(P) pefloxacin (Pelwin, 5% soluble powder, Wockhardt) | 1 part (R) + 1 part (P) is finely ground in equal volumes in a mortar and pestle; thoroughly mix with 5 parts PMMA powder <sup>666</sup> | Rifampin powder taken from oral capsules; pefloxacin powder obtained from the preparation intended for oral use in poultry                                                                                                                             |
| (R) Rifampin/(P) piperacillin                                      | 1 part (R) + 1 part (P) is combined and finely ground in a mortar and pestle; thoroughly mix with 5 parts PMMA powder <sup>666</sup>     | Rifampin powder taken from oral capsules; piperacillin powder taken from parenteral preparation prior to reconstitution                                                                                                                                |

<sup>a</sup> Antimicrobial-impregnated polymethylmethacrylate (PMMA) is used to elute antimicrobial agents for long-term treatment of infected lesions. Following are guidelines for its use and preparation:



- Choose antibiotic based on culture and sensitivity.
- Mix 1-2 g of sterile antibiotic powder with 40-60 g of PMMA powder. Add approximately 2 Tbs to antibiotic at a time. The use of liquid antibiotic reduces the mechanical strength of the bead.
- Shake mixture well (for at least 2 min) to make it homogeneous.
- Add liquid monomer as usual.
- The dough is placed in a catheter tip syringe and extruded, rolled into beads, and placed onto steel surgical wire. Dough may also be injected into a red rubber catheter which may be cut into variable sizes. The smaller the bead, the greater the elution of antibiotic.
- Gas sterilization is recommended; beads are aerated for at least 24 hr at room temperature.
- The wound is aggressively debrided and beads are placed within it; the wound is then closed and the beads are left within the site until the wound is no longer infected.[782,845](#)
- In human medicine, beads are removed after 2-6 wk. Despite their antibiotic release, beads act as a surface to which bacteria preferentially adhere, grow and potentially develop antibiotic resistance.[565](#) Beads are difficult to remove if left in place for more than 14 days.[593](#)
- Discard unused beads after 2 mo.[666](#)

TABLE 5-15 Agents Used in the Treatment of Oiled Birds.

| Agent                                       | Dosage                                      | Species/Comments                                                |
|---------------------------------------------|---------------------------------------------|-----------------------------------------------------------------|
| Bismuth subsalicylate                       | 2-5 mg/kg<br>PO<br>once <a href="#">529</a> | Adsorbent; gavage; alternatively, can use activated charcoal    |
| Charcoal, activated<br>(Toxiban, Vet-A-Mix) | 52 mg/kg<br>PO<br>once <a href="#">529</a>  | Adsorbent; gavage; alternatively, can use bismuth subsalicylate |
|                                             |                                             |                                                                 |

|                                                             |                                   |                                                                                                                                |
|-------------------------------------------------------------|-----------------------------------|--------------------------------------------------------------------------------------------------------------------------------|
| Charcoal, activated/electrolyte slurry (Toxiban, Vet-A-Mix) | 50 mL/kg by gavage <sup>806</sup> | 3 bottles of charcoal slurry (3.75 g/kg) added to 250 mL of electrolyte solution                                               |
| Detergent (Dawn, Procter & Gamble)                          | 1-5% bath <sup>529</sup>          | Submerge bird up to mid-neck region; rinse with water; use water at 103-105°F (39-41°C) and 40-60 psi (pounds per square inch) |
| Fluid therapy                                               | —                                 | See <a href="#">Table 5-36</a> for guidelines                                                                                  |
| Iron dextran                                                | 10 mg/kg IM q5-7d <sup>529</sup>  | If PCV <25%                                                                                                                    |
| Lactulose                                                   | 0.3 mL/kg PO q12h <sup>516</sup>  | Prophylactic laxative                                                                                                          |
| Oral electrolyte solutions (Pedialyte; Ross Labs)           | 30 mL/kg by gavage <sup>806</sup> | Most species/at field stabilization site                                                                                       |
| Papaya enzyme                                               | 1 tablet PO q12h <sup>516</sup>   | Prophylactic laxative                                                                                                          |
| Thiamine/vitamin B <sub>1</sub>                             | 25-30 mg/kg fish <sup>529</sup>   | Piscivorous species                                                                                                            |

TABLE 5-16 Agents Used in Bird Emergencies.

| Agent                      | Dosage                                                    | Species/Comments                                                                                                 |
|----------------------------|-----------------------------------------------------------|------------------------------------------------------------------------------------------------------------------|
| Aminophylline              | 4 mg/kg PO q6-12h <sup>812</sup>                          | Can give orally after initial response                                                                           |
|                            | 10 mg/kg IV q3h <sup>812</sup>                            | Use for pulmonary edema                                                                                          |
| Atropine sulfate           | 0.2 mg/kg IM, IV, IO <sup>650</sup>                       | Bradycardia                                                                                                      |
|                            | 0.5 mg/kg IM, IV, IO, intratracheal <sup>695</sup>        | CPR                                                                                                              |
| Calcium gluconate          | 50-100 mg/kg IM, IV (slow bolus) <sup>365,399,671</sup>   | Hypocalcemia; dilute 50 mg/mL; hyperkalemia; facilitates potassium movement across cell membranes <sup>399</sup> |
| Dexamethasone Na phosphate | 2-6 mg/kg IM, IV q12-24h <sup>387,812</sup>               | Head trauma (until signs abate); shock (one dose); hyperthermia (until stable)                                   |
| Dextrose (50%)             | 50-100 mg/kg IV (slow bolus to effect) <sup>696,812</sup> | Hypoglycemia; can dilute with fluids                                                                             |
|                            | 500-1000 mg/kg IV (slow bolus) <sup>133,634</sup>         | Hypoglycemia; can dilute with fluids                                                                             |

|                                                       |                                                                                           |                                                                                                                                        |
|-------------------------------------------------------|-------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------|
| Dextran 70                                            | 10-20 mL/kg IV <sup><a href="#">147</a></sup>                                             | Most species/hypovolemic shock                                                                                                         |
| Diazepam                                              | 0.5-1 mg/kg IM, IV prn <sup><a href="#">693</a></sup>                                     | Seizures                                                                                                                               |
| Doxapram                                              | 5-10 mg/kg IM, IV once <sup><a href="#">363</a></sup>                                     | Raptors/respiratory depression or arrest                                                                                               |
|                                                       | 20 mg/kg IM, IV, IO <sup><a href="#">692</a></sup>                                        | CPR; respiratory depression                                                                                                            |
| Epinephrine (1:1000)                                  | 0.5-1 mL/kg IM, IV, IO, intratracheal <sup><a href="#">692,695</a></sup>                  | CPR; bradycardia                                                                                                                       |
| Fluids                                                | 10-25 mL/kg IV, IO <sup><a href="#">855</a></sup>                                         | Bolus over 5-7 min                                                                                                                     |
|                                                       | 50-90 mL/kg fluids SC, <sup><a href="#">a</a></sup> IV, IO <sup><a href="#">696</a></sup> | See <a href="#">Table 5-37</a> (fluid therapy)                                                                                         |
| Hemoglobin glutamer-200 (Oxyglobin, OPK Biotech)      | —                                                                                         | Hemoglobin polymer; hemoglobin replacement product; anemia treatment; currently unavailable, but under FDA testing by new manufacturer |
|                                                       | 3-10 mL/kg IV (slow) <sup><a href="#">7</a></sup>                                         | Most species                                                                                                                           |
|                                                       | 5 mL/kg IV <sup><a href="#">457</a></sup>                                                 | Mallard ducks                                                                                                                          |
|                                                       | 10 mL/kg IV <sup><a href="#">363</a></sup>                                                | Raptors                                                                                                                                |
|                                                       | 15 mL/kg IV <sup><a href="#">7</a></sup>                                                  | Chickens/PD; hemoglobin levels fell near zero by 50 min post-administration                                                            |
| Hetastarch                                            | 10-15 mL/kg IV (slow) q8h <sup><a href="#">363,399,774</a></sup> × 1-4 treatments         | Most species, including raptors/hypoproteinemia; hypovolemia                                                                           |
| Mannitol                                              | 0.2-2 mg/kg IV (slow) q24h <sup><a href="#">363,399</a></sup>                             | Raptors/cerebral edema; anuric renal failure                                                                                           |
| Oxyglobin                                             | —                                                                                         | See Hemoglobin glutamer-200                                                                                                            |
| Prednisolone Na succinate (Solu-Delta-Cortef, Upjohn) | 10-20 mg/kg IM, IV q15min prn <sup><a href="#">133</a></sup>                              | Head trauma; CPR                                                                                                                       |
|                                                       | 15-30 mg/kg IV <sup><a href="#">399</a></sup>                                             | Raptors                                                                                                                                |
| Sodium bicarbonate                                    | 1 mEq/kg IV q15-30min to maximum of 4 mEq/kg total dose <sup><a href="#">133</a></sup>    | Metabolic acidosis                                                                                                                     |
|                                                       | 5 mEq/kg IV, IO once <sup><a href="#">692</a></sup>                                       | CPR                                                                                                                                    |
| Terbutaline                                           | 0.01 mg/kg PO, IM q6h <sup><a href="#">455</a></sup>                                      | Psittacines/ $\alpha_2$ -selective smooth muscle bronchodilator                                                                        |
|                                                       | 0.1 mg/kg PO q12-                                                                         | Macaws, Amazon parrots/bronchodilator; obstructive                                                                                     |

<sup>a</sup> Because of the presence of peripheral vasoconstriction, subcutaneous administration is not adequate for patients in shock.

TABLE 5-17 Euthanasia Agents Used in Birds.<sup>a</sup>

| Agent                             | Dosage                                                                    | Species/Comments                                                                                                                        |
|-----------------------------------|---------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------|
| Carbon dioxide (CO <sub>2</sub> ) | 70% <sup>717</sup>                                                        | Most species/danger to person administering gas; compressed gas is the only recommended source <sup>22</sup>                            |
| Carbon monoxide (CO)              | Minimum 6% concentration in a closed container <sup>717</sup>             | Most species/unconsciousness occurs rapidly; inexpensive; <sup>540</sup> danger to person administering gas; compressed gas recommended |
| Isoflurane                        | Saturated cotton ball in closed container or face mask <sup>623,717</sup> | Most species/very rapid induction; wing flapping and vocalizing may occur                                                               |
| Methoxyflurane                    | Saturated cotton ball in closed container or face mask <sup>623,717</sup> | Most species/induction may be slower than with isoflurane                                                                               |
| Pentobarbital sodium              | 0.2-1 mL/kg IV, ICe <sup>617,692</sup>                                    | Most species/birds may react unpredictably with IV administration; ICe administration is smooth, quiet                                  |
| Potassium chloride                | 1-2 mmol/kg IV <sup>22</sup>                                              | Most species/must be provided in conjunction with prior general anesthesia                                                              |

<sup>a</sup> The American Veterinary Medical Association accepts inhalant anesthetic overdose, carbon monoxide, carbon dioxide, and barbiturate overdose as humane euthanasia methods.<sup>23,717</sup> Cervical dislocation and decapitation are conditionally acceptable for research and poultry. Pithing should be used as an adjunctive procedure to ensure death in an animal already rendered unconscious by another method.<sup>23</sup>

TABLE 5-18 Miscellaneous Agents Used in Birds.

| Agent                                          | Dosage                 | Species/Comments                                                                                                                                |
|------------------------------------------------|------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------|
| Acemannan (Carravet, Veterinary Products Labs) | Topical <sup>228</sup> | Most species/hydrogel wound dressing; wound healing; increases cytokine production, fibroblast proliferation, and epidermal growth <sup>a</sup> |
| Acetic acid (apple                             | 15 mL/qt drinking      | Most species/intestinal dysbiosis                                                                                                               |

|                                                        |                                                                                                    |                                                                                                                                                                                                                                                                                     |
|--------------------------------------------------------|----------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| cider vinegar)                                         | water <sup>388</sup>                                                                               |                                                                                                                                                                                                                                                                                     |
| Allopurinol                                            | —                                                                                                  | Xanthine oxidase inhibitor/use in treatment of gout is controversial: 50 mg/kg given to red-tailed hawks was toxic leading to marked elevations in plasma oxypurinol, xanthine, and hypoxanthine with secondary renal dysfunction; <sup>484</sup> maintain hydration <sup>702</sup> |
|                                                        | 10 mg/kg PO q4-12h <sup>690</sup>                                                                  | Most species/prepare suspension; reduce dose as hyperuricemia decreases                                                                                                                                                                                                             |
|                                                        | 10-15 mg/kg PO <sup>102</sup>                                                                      | Psittacines, passerines, raptors                                                                                                                                                                                                                                                    |
|                                                        | 25 mg/kg PO q24h <sup>615,616</sup>                                                                | Red-tailed hawks/PD; no significant effect on plasma uric acid levels                                                                                                                                                                                                               |
|                                                        | 30 mg/kg PO q12h <sup>47</sup>                                                                     | Most species/gout                                                                                                                                                                                                                                                                   |
|                                                        | 830 mg/L drinking water <sup>692</sup>                                                             | Most species                                                                                                                                                                                                                                                                        |
|                                                        | 1 mL stock solution/30 mL drinking water mixed fresh several times daily (300 mg/L) <sup>672</sup> | Budgerigars/decrease initial dose to 25% recommended dose in severe cases and gradually increase over several days; use with colchicine in severe cases; stock solution: 100 mg tablet/10 mL sterile water                                                                          |
| Aloe vera                                              | Topical <sup>228,387</sup>                                                                         | Most species/antiinflammatory; antithromboxane activity; beneficial in treating burns, electrical injury, or dying skin flaps; <sup>a</sup> see heparin for combination                                                                                                             |
| Aluminum hydroxide                                     | 30-90 mg/kg PO q12h <sup>692</sup>                                                                 | Most species/antacid; phosphate binder                                                                                                                                                                                                                                              |
| Aminoloid (Aminoloid, Schering)                        | 0.25-0.75 mg/kg IM, repeat in 10-14 days <sup>702</sup>                                            | Raptors/induction of molt                                                                                                                                                                                                                                                           |
| Aminopentamide hydrogen sulfate (Centrine, Fort Dodge) | 0.05 mg/kg SC, IM q12h up to 5 doses <sup>241</sup>                                                | Most species/regurgitation                                                                                                                                                                                                                                                          |
|                                                        | 0.11 mg/kg SC, IM q8-12h × 1 day, then q12h × 1 day, then q24h × 1 day <sup>76</sup>               | Most species/regurgitation                                                                                                                                                                                                                                                          |
| Aminophylline                                          | 4 mg/kg PO, IM q6-12h <sup>692</sup>                                                               | Most species/bronchodilator; need to prepare as a suspension daily                                                                                                                                                                                                                  |
|                                                        | 5 mg/kg PO, IV q12h <sup>455</sup>                                                                 | Psittacines                                                                                                                                                                                                                                                                         |
|                                                        | 8-10 mg/kg PO, IM,                                                                                 |                                                                                                                                                                                                                                                                                     |

|                                                               |                                                                                       |                                                                                                                                                                                                                                                                                                                |
|---------------------------------------------------------------|---------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                                                               | IV q6-8h <sup>363,810</sup>                                                           | Raptors, ratites                                                                                                                                                                                                                                                                                               |
|                                                               | 10 mg/kg IV q3h, then PO after initial response <sup>332,388</sup>                    | Most species                                                                                                                                                                                                                                                                                                   |
|                                                               | 10 mg/kg IM, IV q8-12h <sup>332</sup>                                                 | Most species/for IV use, dilute in 10-20 mL saline or 5% dextrose in water and inject slowly                                                                                                                                                                                                                   |
| Ammonium solution                                             | Topical prn <sup>672</sup>                                                            | Most species/analgesic; antipruritic; antiinflammatory; can use on fresh wounds; avoid overusage <sup>a</sup>                                                                                                                                                                                                  |
| 9,10 anthraquinone (Flight Control, Environmental Biocontrol) | 12.6 mL/L water, sprayed q7d on dry, grassy areas where geese frequent <sup>778</sup> | Nuisance Canada geese/deterrent if ingested; birds become nauseated and subsequently avoid the area which contains an ultraviolet dye readily detected by the avian eye                                                                                                                                        |
| Anticoagulant citrate dextrose (A-C-D Solution, Sanofi)       | 0.15 mL/1 mL whole blood <sup>378</sup>                                               | Anticoagulant for transfusions; not effective for extended storage of whole blood; <sup>538</sup> heparin can be substituted if A-C-D is not available <sup>378</sup>                                                                                                                                          |
| Armor All Protectant (Armor All Protectant Corp)              | Topical to affected plumage <sup>59</sup>                                             | Most species/soften sticky-trap glue covered plumage; use detergent (Dawn) to remove Armor All                                                                                                                                                                                                                 |
| Barium sulfate                                                | —                                                                                     | Dilute 72% suspension 1:1 with water; dilute 92% suspension 1:2 with water; 60% suspension effective in Amazon parrots; <sup>219</sup> more dilute concentrations (20-25%) can also be used; <sup>b</sup> administer ½ volume diluted barium and ½ volume air for double contrast study of crop <sup>520</sup> |
|                                                               | 20-25 mL/kg PO via gavage <sup>285,835</sup>                                          | Most species                                                                                                                                                                                                                                                                                                   |
|                                                               | 25-50 mL/kg PO <sup>285</sup>                                                         | Most species/smaller species require relatively more contrast media; African grey parrots, 25 mL/kg; Quaker parakeets and budgerigars, 50 mL/kg                                                                                                                                                                |
| Bismuth subsalicylate (Pepto Bismol, Procter & Gamble)        | 1-2 mL/kg PO q12h <sup>437,702,811</sup>                                              | Most species/weak adsorbent, demulcent                                                                                                                                                                                                                                                                         |
|                                                               | 2-5 mL/kg PO once <sup>529</sup>                                                      | Most species/a component of oiled bird treatment; alternatively can use activated charcoal                                                                                                                                                                                                                     |
| Bromhexine HCl                                                | 1.5 mg/kg IM q12-24h <sup>133</sup>                                                   | Most species/expectorant                                                                                                                                                                                                                                                                                       |
|                                                               | 3-6 mg/kg IM <sup>78,147</sup>                                                        | Most species, including psittacines, passerines, raptors                                                                                                                                                                                                                                                       |
|                                                               | 6.5 mg/L drinking water <sup>147</sup>                                                | Psittacines                                                                                                                                                                                                                                                                                                    |
|                                                               | 1200 mg/L drinking water <sup>78</sup>                                                | Most species                                                                                                                                                                                                                                                                                                   |
|                                                               |                                                                                       |                                                                                                                                                                                                                                                                                                                |

|                                                    |                                                                |                                                                                                                                                                                                                                                        |
|----------------------------------------------------|----------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Cimetidine                                         | —                                                              | Prototype histamine-2 blocker used to reduce GI acid production                                                                                                                                                                                        |
|                                                    | 3-5 mg/kg PO, IV q8h <sup><a href="#">810</a></sup>            | Ratites                                                                                                                                                                                                                                                |
|                                                    | 5 mg/kg PO, IM q8-12h <sup><a href="#">692</a></sup>           | Psittacines/proventriculitis; gastric ulceration                                                                                                                                                                                                       |
|                                                    | 5-10 mg/kg IM q12h <sup><a href="#">810</a></sup>              | Ratites                                                                                                                                                                                                                                                |
| Cisapride (Propulsid, Janssen)                     | —                                                              | Gastrointestinal prokinetic agent, stimulates motility; <sup><a href="#">614</a></sup> not commercially available in the United States; can be compounded                                                                                              |
|                                                    | 0.25 mg/kg PO q8h <sup><a href="#">149</a></sup>               | Raptors/gastrointestinal stimulant                                                                                                                                                                                                                     |
|                                                    | 0.5-1.5 mg/kg PO q8h <sup><a href="#">388</a></sup>            | Most species                                                                                                                                                                                                                                           |
|                                                    | 1 mg/kg PO q12h <sup><a href="#">190</a></sup>                 | Psittacines/ileus                                                                                                                                                                                                                                      |
| Citrate phosphate dextrose adenine solution (CPDA) | 1 part CPDA:5 parts whole blood <sup><a href="#">538</a></sup> | Most species/anticoagulant for blood collection for transfusion; not for extended storage of whole blood                                                                                                                                               |
| Citric acid                                        | 5000 mg/L drinking water <sup><a href="#">147</a></sup>        | Most species/reduces the effect of calcium and magnesium on the absorption of tetracyclines                                                                                                                                                            |
| Colchicine                                         | —                                                              | Unique antiinflammatory used in the treatment of gout or hepatic fibrosis/cirrhosis; <sup><a href="#">614</a></sup> may potentiate gout formation in some cases <sup><a href="#">671</a></sup>                                                         |
|                                                    | 0.01 mg/kg PO q12h <sup><a href="#">140</a></sup>              | Juvenile macaws/gout                                                                                                                                                                                                                                   |
|                                                    | 0.04 mg/kg PO q12-24h <sup><a href="#">353</a></sup>           | Most species/gradually increase to q12h <sup><a href="#">812</a></sup>                                                                                                                                                                                 |
|                                                    | 0.2 mg/kg PO q12h <sup><a href="#">672</a></sup>               | Psittacines                                                                                                                                                                                                                                            |
| Copper sulfate (Cu-7, Searle)                      | Topical <sup><a href="#">702</a></sup>                         | Most species/ulcerative dermatitis                                                                                                                                                                                                                     |
| Detergent (Dawn, Procter & Gamble)                 | 1-5% bath <sup><a href="#">516</a></sup>                       | Most species/Armor All, motor oil removal                                                                                                                                                                                                              |
| Dextran 70                                         | 10-20 mL/kg IV <sup><a href="#">147</a></sup>                  | Most species/hypovolemic shock; colloid with a $t_{1/2}$ shorter than hetastarch                                                                                                                                                                       |
| Digoxin                                            | —                                                              | Toxic reactions include depression, ataxia, vomiting, diarrhea; contraindicated with renal or liver disease; <sup><a href="#">433</a></sup> monitoring of serum digoxin, potassium, magnesium, calcium, and ECG is recommended; induced arrhythmias in |



|                                               |                                                           |                                                                                                                                                                                                                                                                                                     |
|-----------------------------------------------|-----------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                                               | 0.0035 mg/kg IV q24h <sup>16</sup>                        | pigeons at 0.2 mg/kg/day <sup>530</sup><br>Turkeys                                                                                                                                                                                                                                                  |
|                                               | 0.0049 mg/kg IV q12h <sup>16</sup>                        | Poultry                                                                                                                                                                                                                                                                                             |
|                                               | 0.01 mg/kg PO q24h × 6 wk <sup>20</sup>                   | Chickens/ascites syndrome; reduced ascites; no apparent toxicity                                                                                                                                                                                                                                    |
|                                               | 0.01-0.02 mg/kg PO q12h <sup>147</sup>                    | Psittacines, passerines, raptors/congestive heart disease                                                                                                                                                                                                                                           |
|                                               | 0.019 mg/kg IV q12h <sup>16</sup>                         | Pekin ducks                                                                                                                                                                                                                                                                                         |
|                                               | 0.02 mg/kg PO q24h × 5 days <sup>311</sup>                | Parakeets, sparrows (PD)/produces a plasma concentration of 1.6 µg/mL (within mammalian therapeutic range); this dose led to signs of toxicity in a mynah <sup>687</sup>                                                                                                                            |
|                                               | 0.05 mg/kg PO q24h <sup>858</sup>                         | Quaker parakeets/PD; congestive heart failure; cardiomyopathy                                                                                                                                                                                                                                       |
|                                               | 0.13 mg/L drinking water <sup>147</sup>                   | Psittacines, passerines, raptors/congestive heart disease                                                                                                                                                                                                                                           |
| Dimethylsulfoxide (90%)                       | 1 mL/kg topical to affected area q4-7d <sup>388,671</sup> | Most species/antiinflammatory, analgesic; systemic absorption; use gloves during application                                                                                                                                                                                                        |
| Dioctyl sodium sulfosuccinate                 | 33 mL/L drinking water <sup>402</sup>                     | Psittacine chicks/constipation; use only if chick is drinking                                                                                                                                                                                                                                       |
| Diphenhydramine                               | 1-4 mg/kg PO q8h <sup>692</sup>                           | Macaws, Amazon parrots/allergic rhinitis, hypersensitivity                                                                                                                                                                                                                                          |
|                                               | 2 mg/kg PO q12h <sup>730</sup>                            | Psittacines/pruritis                                                                                                                                                                                                                                                                                |
|                                               | 2 mg/kg IV, IO once <sup>269</sup>                        | Cockatoos/use prior to chemotherapy                                                                                                                                                                                                                                                                 |
|                                               | 2-4 mg/kg PO, IM, IV q12h <sup>387,388</sup>              | Most species/has calming effect in some anxious birds; may cause hypotension                                                                                                                                                                                                                        |
|                                               | 20-40 mg/L drinking water <sup>275</sup>                  | Most species                                                                                                                                                                                                                                                                                        |
| Diphenoxylate with atropine (Lomotil, Searle) | 2-2.5 mg/kg PO q8h <sup>810</sup>                         | Ratites/opiate; gastrointestinal motility modifier                                                                                                                                                                                                                                                  |
| EDTA-tromethamine or EDTA-Tris                | IT, intranasal, or wound lavage <sup>702</sup>            | Most species/potentiates the effect of antibiotics on resistant bacteria; <sup>227</sup> 1.2 g EDTA + 6.05 g Tris added to 1 L sterile water, pH adjusted to 8 with a dilute solution of sodium hydroxide, autoclaved × 15 min; Tris-EDTA may also be added to chlorhexidine solution <sup>32</sup> |
|                                               | 0.2-0.5 mg/kg                                             |                                                                                                                                                                                                                                                                                                     |



|                                             |                                                                          |                                                                                                                                                             |
|---------------------------------------------|--------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Enalapril                                   | q24h <sup><a href="#">388</a></sup>                                      | Most species                                                                                                                                                |
|                                             | 0.25-0.5 mg/kg PO q24-48h <sup><a href="#">30,617</a></sup>              | Psittacines/dilated cardiomyopathy; monitor uric acid levels; reduce dose or discontinue if concurrent renal disease                                        |
|                                             | 1.25 mg/kg PO q8-12h <sup><a href="#">601</a></sup>                      | Pigeons, Amazon parrots/PD                                                                                                                                  |
|                                             | 2.5-5 mg/kg PO q12h <sup><a href="#">602</a></sup>                       | Amazon parrot/right-sided heart failure; long term therapy                                                                                                  |
|                                             | 5 mg/kg PO q24h <sup><a href="#">c</a></sup>                             | Lovebirds                                                                                                                                                   |
| Ferric subsulfate                           | Topical <sup><a href="#">672</a></sup>                                   | Most species/hemostasis of bleeding nail or beak tip; will cause necrosis if used on open skin lesions                                                      |
| Furosemide                                  | —                                                                        | Diuretic; overdose can cause dehydration and electrolyte abnormalities; toxicity characterized by neurologic signs and death <sup><a href="#">702</a></sup> |
|                                             | 0.1-2 mg/kg PO, SC, IM, IV q6-24h <sup><a href="#">433,671,702</a></sup> | Most species, including psittacines, raptors/lories are extremely sensitive <sup><a href="#">671,812</a></sup>                                              |
|                                             | 0.15 mg/kg IM <sup><a href="#">402</a></sup>                             | Psittacine neonates/pulmonary congestion                                                                                                                    |
|                                             | 0.15 mg/kg IM q8h <sup><a href="#">411</a></sup>                         | Mynahs/ascites, hemochromatosis                                                                                                                             |
|                                             | 0.5-1 mg/kg IM q12-24h <sup><a href="#">102,812</a></sup>                | Pigeons, raptors, mynahs, ostriches/cardiac disease, ascites                                                                                                |
|                                             | 1-2.2 mg/kg PO q12-24h <sup><a href="#">574,687,693</a></sup>            | Most species                                                                                                                                                |
|                                             | 2-5 mg/kg IM <sup><a href="#">363,399</a></sup>                          | Raptors                                                                                                                                                     |
|                                             | 2.5-10 mg/kg PO q12h × 7-14 days <sup><a href="#">692</a></sup>          | Cockatiels, budgerigars/ascites                                                                                                                             |
|                                             | 4-6 mg/kg PO, IM <sup><a href="#">649</a></sup>                          | Raptors/pulmonary congestion                                                                                                                                |
|                                             | 40 mg/L drinking water <sup><a href="#">692</a></sup>                    | Most species/congestive heart failure; can be used with digoxin and ACE inhibitors                                                                          |
| Gadopentate dimeglumine (Magnevist, Berlex) | 0.25 mmol/kg IV <sup><a href="#">682</a></sup>                           | Contrast agent for magnetic resonance imaging                                                                                                               |
| Gallium-67 citrate (Ga-67)                  | 0.5 mCi (microcuries)/bird IV <sup><a href="#">407</a></sup>             | Green-winged macaws/radiopharmaceutical used for detection of infection and inflammatory lesions; requires a gamma camera for imaging                       |
|                                             |                                                                          | Psittacines/lipid regulating agent; yolk emboli; sometimes                                                                                                  |

|                                                           |                                                                                |                                                                                                                                                                                                                                                                                                                                                            |
|-----------------------------------------------------------|--------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Gemfibrozil                                               | 30 mg/kg PO q8h <sup>632</sup>                                                 | effective in controlling signs; gradual improvement may be                                                                                                                                                                                                                                                                                                 |
| Gentian violet<br>(crystal violet)                        | Topical <sup>149</sup>                                                         | seen over weeks to months; give with niacin<br>Raptors/wound management                                                                                                                                                                                                                                                                                    |
| Glipizide                                                 | —                                                                              | Sulfonylurea antidiabetic; contraindicated in ketotic<br>patients; patients should be maintained at trace glucosuria<br>to prevent hypoglycemia <sup>618</sup>                                                                                                                                                                                             |
|                                                           | 0.5 mg/kg PO<br>q12h <sup>618</sup>                                            | Cockatiels/diabetes mellitus                                                                                                                                                                                                                                                                                                                               |
|                                                           | 1.25 mg/kg PO<br>q24h <sup>388</sup>                                           | Most species/diabetes mellitus                                                                                                                                                                                                                                                                                                                             |
| Glycosaminoglycan                                         | —                                                                              | See polysulfated glycosaminoglycan                                                                                                                                                                                                                                                                                                                         |
| Guaifenesin                                               | 0.8 mg/kg PO<br>q12h <sup>613</sup>                                            | Severe macaws/expectorant, bronchodilation                                                                                                                                                                                                                                                                                                                 |
| Hemoglobin<br>glutamer-200<br>(Oxyglobin, OPK<br>Biotech) | —                                                                              | Hemoglobin polymer; hemoglobin replacement product;<br>anemia treatment; but under FDA testing by new<br>manufacturer; mean $2.7 \pm 1.9$ mL/kg IV administered to<br>cockatiels to replace blood (1.6-2.5 mL) removed by<br>phlebotomy; 2/11 birds died; no adverse reactions were<br>recognized in surviving birds; <sup>459</sup> currently unavailable |
|                                                           | 3-10 mL/kg IV<br>(slow) <sup>7</sup>                                           | Most species                                                                                                                                                                                                                                                                                                                                               |
|                                                           | 5 mL/kg IV <sup>457</sup>                                                      | Mallard ducks/PD                                                                                                                                                                                                                                                                                                                                           |
|                                                           | 10 mL/kg IV <sup>363</sup>                                                     | Raptors                                                                                                                                                                                                                                                                                                                                                    |
|                                                           | 15 mL/kg IV <sup>7</sup>                                                       | Chickens/PD; hemoglobin levels fell near zero by 50 min<br>post-administration                                                                                                                                                                                                                                                                             |
| Heparin                                                   | 2 U/mL whole<br>blood <sup>180</sup>                                           | Cockatiels, conures/anticoagulant for blood transfusions                                                                                                                                                                                                                                                                                                   |
| Heparin/aloe vera                                         | Topical to affected<br>area <sup>387</sup>                                     | Most species/antiinflammatory; dilute 1000 U heparin/150<br>mg aloe vera <sup>a</sup>                                                                                                                                                                                                                                                                      |
| Hetastarch<br>(Hespan, DuPont)                            | —                                                                              | Colloid with a $t_{1/2}$ of 25 hr; use with caution in patients<br>suffering from congestive heart failure or renal failure                                                                                                                                                                                                                                |
|                                                           | 10-15 mL/kg IV<br>q8h $\times$ 1-4<br>treatments <sup>363,399,774</sup>        | Most species/chronic hypoproteinemia; decrease fluid<br>treatment to $\frac{1}{3}$ - $\frac{1}{2}$ maintenance fluid dose                                                                                                                                                                                                                                  |
| Hyaluronidase                                             | 5 U/kg IV q12h $\times$ 1-<br>3 days then 2 $\times$ /wk<br>prn <sup>463</sup> | Psittacines/egg-yolk related disease; egg yolk visually<br>apparent in blood or serum; dilute with an equal or greater<br>quantity of isotonic NaCl                                                                                                                                                                                                        |
|                                                           | 75-150 U/L<br>fluids <sup>399,463</sup>                                        | Most species/increases absorption rate of fluids <sup>271</sup>                                                                                                                                                                                                                                                                                            |
| Hydroxyzine                                               | 2-2.2 mg/kg PO                                                                 | Amazon parrots/allergic pruritus; feather picking; self-                                                                                                                                                                                                                                                                                                   |

|                                                         |                                                                                        |                                                                                                                                                                                                    |
|---------------------------------------------------------|----------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| (Atarax, Roerig)                                        | q8h <a href="#">292,436</a><br>34-40 mg/L<br>drinking<br>water <a href="#">275,292</a> | mutilation<br><br>Most species/respiratory allergy; feather picking                                                                                                                                |
| Iohexol<br>(Omnipaque,<br>Sanofi Winthrop)              | 25-30 mL/kg<br>PO <a href="#">219,285</a>                                              | Cockatoos, Amazon parrots/gavage; radiographic<br>gastrointestinal iodinated contrast media; 1:1 dilution with<br>water can also be used                                                           |
|                                                         | 50 mL/kg PO <a href="#">285</a>                                                        | Quaker parakeets, budgerigars                                                                                                                                                                      |
| Isoxsuprine                                             | 5-10 mg/kg PO<br>q24h × 20-40 days <a href="#">63</a>                                  | Raptors/peripheral vasodilator; wing tip edema                                                                                                                                                     |
|                                                         | 10 mg/kg PO<br>q24h <a href="#">738</a>                                                | Amazon parrots/atherosclerosis                                                                                                                                                                     |
| Kaolin/pectin                                           | 2 mL/kg PO q6-<br>12h <a href="#">401,702</a>                                          | Psittacine neonates/intestinal protectant, antidiarrheal                                                                                                                                           |
|                                                         | ≤15 mL/kg PO,<br>repeat prn <a href="#">149</a>                                        | Raptors                                                                                                                                                                                            |
| Lactulose                                               | —                                                                                      | Does not treat liver disease; <a href="#">193</a> reduces blood ammonia<br>levels; exerts osmotic effect in birds with caeca through<br>fermentation to acetic and lactic acid <a href="#">614</a> |
|                                                         | 150-650 mg/kg<br>(0.2-1 mL/kg) PO<br>q8-12h <a href="#">47,500,702,812</a>             | Most species, including psittacines/hepatic encephalopathy                                                                                                                                         |
|                                                         | 200 mg/kg (0.3<br>mL/kg) PO q8-<br>12h <a href="#">401</a>                             | Psittacine neonates                                                                                                                                                                                |
|                                                         | 300 mg/kg PO<br>q12h <a href="#">582</a>                                               | Chattering lories                                                                                                                                                                                  |
| Magnesium<br>hydroxide<br>(M)/activated<br>charcoal (C) | (M) 10-12 mL + (C)<br>1 tsp powder PO <a href="#">437</a>                              | Most species/cathartic; adsorbent                                                                                                                                                                  |
| Magnesium sulfate<br>(Epsom salts)                      | —                                                                                      | Purgative, cathartic; may cause lethargy; <a href="#">437</a> see peanut<br>butter for combination                                                                                                 |
|                                                         | 0.25-1 g/kg PO<br>q24h × 1-2<br>days <a href="#">149,437</a>                           | Most species, including raptors                                                                                                                                                                    |
|                                                         | ¼ tsp/bird PO <a href="#">810</a>                                                      | Ratite juveniles/obstipation                                                                                                                                                                       |
|                                                         | 2 Tbs/bird PO <a href="#">810</a>                                                      | Ratite adults/obstipation                                                                                                                                                                          |
| Mannitol                                                | —                                                                                      | Osmotic diuretic used to treat cerebral edema, especially<br>after head trauma; may be used with furosemide                                                                                        |
|                                                         | 0.25-2 mg/kg q24h                                                                      |                                                                                                                                                                                                    |

|                                     |                                                              |                                                                                                                                                                                                      |
|-------------------------------------|--------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                                     | IV (slow bolus) <a href="#">399,671</a>                      | Most species, including raptors                                                                                                                                                                      |
|                                     | 1500 mg/kg IV q6h <a href="#">810</a>                        | Ratites                                                                                                                                                                                              |
| Methocarbamol                       | 32.5 mg/kg PO q12h <a href="#">672</a>                       | Swans, cranes (demoiselle)/capture myopathy                                                                                                                                                          |
|                                     | 50 mg/kg IV (slow bolus) <a href="#">142,672</a>             | Most species, including swans, Demoiselle cranes/muscle relaxation; capture myopathy; may be given q12h for muscle relaxation                                                                        |
| Metoclopramide                      | —                                                            | Gastrointestinal motility disorders; regurgitation; slow crop motility; no alterations in motility observed after a single dose of 1 mg/kg IM <a href="#">84</a>                                     |
|                                     | 0.1 mg/kg IV <a href="#">810</a>                             | Ostriches                                                                                                                                                                                            |
|                                     | 0.3 mg/kg PO, IM, IV <a href="#">511</a>                     | Most species                                                                                                                                                                                         |
|                                     | 0.5 mg/kg PO, IM, IV q8-12h <a href="#">671</a>              | Most species, including psittacines/gastrointestinal ileus; regurgitation                                                                                                                            |
|                                     | 2 mg/kg IM, IV q8-12h <a href="#">63,125,656</a>             | Raptors, waterfowl/crop stasis; ileus                                                                                                                                                                |
|                                     | 12.5 mg/kg PO <a href="#">810</a>                            | Ratites/gastrointestinal disorders                                                                                                                                                                   |
| Mineral oil                         | —                                                            | Cathartic; used to aid passage of grit and other foreign bodies; administer directly into the crop because oral administration may result in aspiration pneumonia; see peanut butter for combination |
|                                     | ≤5 mL/kg via gavage or per cloaca <a href="#">149,324</a>    | Most species, including psittacines, raptors                                                                                                                                                         |
|                                     | 5-10 mL/kg PO via gavage <a href="#">437,812</a>             | Most species, including psittacines/cathartic                                                                                                                                                        |
|                                     | 15 mL/kg PO via gavage <a href="#">810</a>                   | Ratite adults/impaction                                                                                                                                                                              |
| Nicarbazin (Ovocontrol, Innolytics) | —                                                            | Inhibits sperm receptor sites on the vitelline membrane to prevent fertilization of eggs; check federal and state permit requirements prior to use                                                   |
|                                     | Formulated pellets provided at baiting stations <sup>d</sup> | Pigeons, waterfowl/egg hatch control                                                                                                                                                                 |
| Oxyglobin                           | —                                                            | See Hemoglobin glutamer-200                                                                                                                                                                          |
| Peanut butter                       | Peanut butter and mineral oil (2:1) <a href="#">437</a>      | Most species/add to diet; cathartic                                                                                                                                                                  |

|                                                            |                                                                                        |                                                                                                                                                                                                                                    |
|------------------------------------------------------------|----------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                                                            | Dilute peanut butter and magnesium sulfate <sup><a href="#">437</a></sup>              | Most species/add to diet; cathartic; dilute with water                                                                                                                                                                             |
| Policosanol                                                | 0.3-2 mg PO q25h <sup><a href="#">255</a></sup>                                        | Psittacines/hyperlipidemia; use was reported in 2 birds                                                                                                                                                                            |
| Polysulfated glycosaminoglycan (PSGAG) (Adequan, Luitpold) | 5 mg/kg IM q7d <sup><a href="#">617</a></sup>                                          | Pekin ducks/degenerative joint disease                                                                                                                                                                                             |
|                                                            | 10 mg/kg IM, IA q7d × 3 mo <sup><a href="#">777</a>,<a href="#">809</a></sup>          | Most species, including pheasants, vultures, cranes/noninfectious or traumatic joint dysfunction; 250 mg/mL for intraarticular use; 500 mg/mL for IM use                                                                           |
|                                                            | 500 mg/bird IM q4d × 7 treatments <sup><a href="#">810</a></sup>                       | Ratites                                                                                                                                                                                                                            |
| Povidone iodine                                            | Topical, wash off within 5 min <sup><a href="#">63</a></sup>                           | Raptors/wound cleansing                                                                                                                                                                                                            |
| Probenecid                                                 | —                                                                                      | Not currently recommended for the treatment of gout; may exacerbate the condition <sup><a href="#">5</a></sup>                                                                                                                     |
|                                                            | 125 mg/kg PO q6h <sup><a href="#">140</a></sup>                                        | Macaw chicks/antigout                                                                                                                                                                                                              |
| Probucol (Lorelco, Marion Merrell Dow)                     | 1 drop stock/300 g PO q12h × 2-4 mo <sup><a href="#">387</a>,<a href="#">672</a></sup> | Most species/low density lipoprotein-cholesterolemia; contains iron: use cautiously in species susceptible to hemochromatosis; may increase bile acids; use with low fat diet; prepare stock: crush 250 mg tablet/7.5 mL lactulose |
| Propentofylline (Vivitonin, Hoechst)                       | 5 mg/kg PO q12h × 20-40 days <sup><a href="#">149</a></sup>                            | Raptors/wing-tip edema; dry gangrene syndrome                                                                                                                                                                                      |
| Propranolol                                                | 0.04 mg/kg IV (slow) <sup><a href="#">671</a></sup>                                    | Most species/supraventricular arrhythmia, atrial flutter, fibrillation                                                                                                                                                             |
|                                                            | 0.2 mg/kg IM <sup><a href="#">671</a></sup>                                            |                                                                                                                                                                                                                                    |
| Psyllium (Metamucil, Procter & Gamble)                     | 0.5 tsp/60 mL hand feeding formula <sup><a href="#">437</a></sup>                      | Most species/bulk diet; can use mineral oil as alternative or in addition to psyllium                                                                                                                                              |
|                                                            | 1 Tbs/60 mL water/bird PO, up to 120 mL/day <sup><a href="#">810</a></sup>             | Ratite chicks/impaction                                                                                                                                                                                                            |
| Silymarin (milk thistle)                                   | 50-75 mg/kg PO q12h <sup><a href="#">193</a></sup>                                     | Most species                                                                                                                                                                                                                       |
|                                                            | 100-150 mg/kg PO divided q8-12h <sup><a href="#">29</a></sup>                          | Most species/hepatic antioxidant; use in patients with liver disease and as ancillary to chemotherapy; use a low-alcohol or alcohol-free liquid formulation                                                                        |
| Skin-So-Soft (Avon)                                        | Topical to affected plumage <sup><a href="#">59</a></sup>                              | Most species/softens and removes sticky-trap glue from plumage; use Dawn dish detergent to remove Skin-So-Soft product <sup><a href="#">a</a></sup>                                                                                |

|                                                                      |                                                                            |                                                                                                                                                                                                                         |
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| Sucralfate                                                           | 25 mg/kg PO q8h <sup>671</sup>                                             | Most species, including raptors/oral, esophageal, gastric, duodenal ulcers; give 1 hr before food or other drugs <sup>812</sup>                                                                                         |
| <sup>99m</sup> Techetium-disofenin                                   | 1 mCi (microcuries) <sup>179</sup> in a commercial liquid or solid diet PO | African grey parrots/radionucleotide used for gastrointestinal scintigraphy in birds                                                                                                                                    |
| <sup>99m</sup> Techetium-diethylene-triaminepenta-acetic acid (DTPA) | 42 ± 0.16 MBq (1.158 ± 0.164 mCi [microcuries])/bird IV <sup>505</sup>     | Pigeons/PD; radiopharmaceutical agent of choice for the assessment of renal function                                                                                                                                    |
| Terbutaline                                                          | 0.01 mg/kg PO, IM q6h <sup>455</sup>                                       | Psittacines/ $\alpha_2$ -selective smooth muscle bronchodilator                                                                                                                                                         |
|                                                                      | 0.1 mg/kg PO q12-24h <sup>692</sup>                                        | Macaws, Amazon parrots/bronchodilator; obstructive pulmonary disease; pneumonitis                                                                                                                                       |
| Theophylline                                                         | 2 mg/kg PO q12h <sup>613</sup>                                             | Severe macaws/bronchodilation                                                                                                                                                                                           |
| Tincture of iodine                                                   | Topical <sup>149</sup>                                                     | Raptors/wounds; inexpensive; readily available in undeveloped countries                                                                                                                                                 |
| Trypsin-balsam of Peru-castor oil (Granulex, Pfizer)                 | Topical <sup>228</sup>                                                     | Most species/digests necrotic tissue (may have debriding action); may have analgesic effects; may cause local inflammation and pyogenic reaction; do not use for long term management <sup>a</sup>                      |
| Tyrode's solution                                                    | Offer in place of drinking water <sup>672</sup>                            | Cockatiels/restores renal-medullary gradient; add 8 g NaCl, 0.13 g CaCl <sub>2</sub> , 0.2 g KCl, 0.1 g MgCl <sub>2</sub> , 0.05 g Na <sub>2</sub> HPO <sub>4</sub> , 1 g NaHCO <sub>3</sub> , 1 g glucose to 1 L water |
| Urate oxidase (Uricozyme, Sanofi Winthrop)                           | 100-200 U/kg IM q24h <sup>615,616</sup>                                    | Red-tailed hawks, pigeons/PD; significantly lowered plasma uric acid, including postprandial plasma uric acid                                                                                                           |
| Vegetable oil                                                        | 15 mL/kg PO <sup>810</sup>                                                 | Ratites/impaction                                                                                                                                                                                                       |
| Yeast cell derivatives (Preparation H, WhiteHall)                    | Topical q24h <sup>812</sup>                                                | Most species/pododermatitis; stimulation of epithelialization; one of the four commercial products contains 1% hydrocortisone <sup>a</sup>                                                                              |

<sup>a</sup> Many topical agents contain oils which adhere to plumage. These agents should be used sparingly and generally in non-feathered regions to prevent losing the insulative properties of the plumage.

<sup>b</sup> Sander JE. Personal communication. 1996.

<sup>c</sup> Straub J. Personal communication. 2003.





TABLE 5-19 Hematologic and Serum Biochemical Values of Selected Psittaciformes.<sup>a</sup>

| Measurement               | African Grey Parrot<br>( <i>Psittacus erithacus</i> ) <sup>173,472,518</sup> | Amazon Parrots<br>( <i>Amazona</i> spp) <sup>173,472,518</sup> |
|---------------------------|------------------------------------------------------------------------------|----------------------------------------------------------------|
| Hematology                |                                                                              |                                                                |
| PCV (%)                   | 40-55                                                                        | 40-55                                                          |
| RBC (10 <sup>6</sup> /μL) | 2.4-4.5                                                                      | 2.4-4.5                                                        |
| Hgb (g/dL)                | 11-16                                                                        | 12.2-15.9                                                      |
| MCV (fL)                  | 90-180                                                                       | 160-175                                                        |
| MCH (pg)                  | 28-52                                                                        | 47.2-56.8                                                      |
| MCHC (g/dL)               | 23-33                                                                        | 29.1-31.9                                                      |
| WBC (10 <sup>3</sup> /μL) | 5-15                                                                         | 6-17                                                           |
| Heterophils (%)           | 45-75                                                                        | 30-80                                                          |
| Lymphocytes (%)           | 20-50                                                                        | 20-65                                                          |
| Monocytes (%)             | 0-3                                                                          | 0-3                                                            |
| Eosinophils (%)           | 0-2                                                                          | 0-1                                                            |
| Basophils (%)             | 0-5                                                                          | 0-5                                                            |
| H:L ratio                 | —                                                                            | —                                                              |
| Chemistries               |                                                                              |                                                                |
| ALP (U/L)                 | 12-160                                                                       | 15-150                                                         |
| ALT (U/L)                 | —                                                                            | —                                                              |
| Amylase (U/L)             | 415-626                                                                      | 184-478                                                        |
| AST (U/L)                 | 100-350                                                                      | 130-350                                                        |
| Bile acid (μmol/L)        |                                                                              |                                                                |
| RIA                       | 18-71                                                                        | 19-144                                                         |
| Colorimetric              | 12-96                                                                        | 33-154                                                         |
| Calcium (mg/dL)           | 8-13                                                                         | 8-13                                                           |
| Chloride (mEq/L)          | —                                                                            | —                                                              |
| Cholesterol (mg/dL)       | 160-425                                                                      | —                                                              |
| CK (U/L)                  | 123-875                                                                      | 45-265                                                         |
| Creatinine (mg/dL)        | 0.1-0.4                                                                      | 0.1-0.4                                                        |
| GGT (U/L)                 | 1-10                                                                         | —                                                              |



| Measurement           | African Grey Parrot<br>( <i>Psittacus erithacus</i> ) <sup>773,872,918</sup> | Amazon Parrots<br>( <i>Amazona</i> spp) <sup>773,872,918</sup> |
|-----------------------|------------------------------------------------------------------------------|----------------------------------------------------------------|
| Glucose (mg/dL)       | 190-350                                                                      | 220-350                                                        |
| LDH (U/L)             | 150-450                                                                      | 160-420                                                        |
| Phosphorus (mg/dL)    | 3.2-5.4                                                                      | 3.1-5.5                                                        |
| Potassium (mEq/L)     | 2.6-4.2                                                                      | 3-4.5                                                          |
| Protein, total (g/dL) | 3-5                                                                          | 3-5                                                            |
| Albumin (g/dL)        | 1.57-3.23                                                                    | 1.9-3.5                                                        |
| Globulin (g/dL)       | —                                                                            | —                                                              |
| A:G ratio             | 1.6-4.3                                                                      | 1.9-5.9                                                        |
| Prealbumin (g/dL)     | 0.03-1.35                                                                    | 0.35-1.05                                                      |
| α-globulin (g/dL)     | 0.02-0.27 (α <sub>1</sub> )                                                  | 0.05-0.32 (α <sub>1</sub> )                                    |
| β-globulin (g/dL)     | 0.12-0.31 (α <sub>2</sub> )                                                  | 0.07-0.32 (α <sub>2</sub> )                                    |
| γ-globulin (g/dL)     | 0.15-0.56                                                                    | 0.12-0.72                                                      |
| γ-globulin (g/dL)     | 0.11-0.71                                                                    | 0.17-0.76                                                      |
| Sodium (mEq/L)        | 134-152                                                                      | 136-152                                                        |
| Uric acid (mg/dL)     | 4-10                                                                         | 2-10                                                           |

| Measurement | Budgerigar<br>Parakeet ( <i>Melopsittacus undulatus</i> ) <sup>773,780,818</sup> | Caique<br>( <i>Pionites</i> spp.) <sup>773</sup> | Cockatiel ( <i>Nymphicus hollandicus</i> ) <sup>88,277,818</sup> |
|-------------|----------------------------------------------------------------------------------|--------------------------------------------------|------------------------------------------------------------------|
|-------------|----------------------------------------------------------------------------------|--------------------------------------------------|------------------------------------------------------------------|

|                           |        |       |         |
|---------------------------|--------|-------|---------|
| Hematology                |        |       |         |
| PCV (%)                   | 44-58  | 47-55 | 45-54   |
| RBC (10 <sup>6</sup> /μL) | 2.3-4  | —     | 2.5-4.7 |
| Hgb (g/dL)                | 13-18  | —     | 11-16   |
| MCV (fL)                  | 90-190 | —     | 90-200  |
| MCH (pg)                  | 27-59  | —     | 28-55   |
| MCHC (g/dL)               | 22-32  | —     | 22-33   |
| WBC (10 <sup>3</sup> /μL) | 3-8.5  | 8-15  | 5-13    |

Continued

| Measurement           | Budgerigar<br>Parakeet ( <i>Melopsittacus undulatus</i> ) <sup>172,180,218</sup> | Caique<br>( <i>Pionites</i> spp.) <sup>173</sup> | Cockatiel ( <i>Nymphicus hollandicus</i> ) <sup>18,173,218</sup> |
|-----------------------|----------------------------------------------------------------------------------|--------------------------------------------------|------------------------------------------------------------------|
| Heterophils (%)       | 40-75                                                                            | 39-72                                            | 40-70                                                            |
| Lymphocytes (%)       | 20-45                                                                            | 20-61                                            | 25-55                                                            |
| Monocytes (%)         | 0-2                                                                              | 0-2                                              | 0-2                                                              |
| Eosinophils (%)       | 0-1                                                                              | 0-1                                              | 0-2                                                              |
| Basophils (%)         | 0-1                                                                              | 0-1                                              | 0-6                                                              |
| H:L ratio             | 0.9-3.3                                                                          | —                                                | 0.7-2.8                                                          |
| Chemistries           |                                                                                  |                                                  |                                                                  |
| ALP (U/L)             | 10-80                                                                            | —                                                | 0-346                                                            |
| ALT (U/L)             | —                                                                                | —                                                | 0-9                                                              |
| Amylase (U/L)         | 302-560                                                                          | 244-290                                          | 205-490                                                          |
| AST (U/L)             | 55-154                                                                           | 118-364                                          | 100-396                                                          |
| Bile acid (μmol/L)    |                                                                                  |                                                  |                                                                  |
| RIA                   | 20-65                                                                            | —                                                | 25-85                                                            |
| Colorimetric          | 32-117                                                                           | 12-112                                           | 15-139                                                           |
| BUN (mg/dL)           | 3-5.2                                                                            | —                                                | 2.9-5                                                            |
| Calcium (mg/dL)       | 6.4-11.2                                                                         | 8.3-11.1                                         | 8.5-13                                                           |
| Chloride (mEq/L)      | —                                                                                | —                                                | —                                                                |
| Cholesterol (mg/dL)   | 145-275                                                                          | 126-220                                          | 140-360                                                          |
| CK (U/L)              | 54-252                                                                           | 124-384                                          | 30-245                                                           |
| Creatinine (mg/dL)    | 0.1-0.4                                                                          | —                                                | 0.1-0.4                                                          |
| GGT (U/L)             | 1-10                                                                             | —                                                | 0-5                                                              |
| Glucose (mg/dL)       | 254-399                                                                          | 170-372                                          | 200-450                                                          |
| LDH (U/L)             | 154-271                                                                          | 147-270                                          | 125-450                                                          |
| Phosphorus (mg/dL)    | 3-5.2                                                                            | —                                                | 3.2-4.8                                                          |
| Potassium (mEq/L)     | 2.2-3.7                                                                          | —                                                | 2.5-4.5                                                          |
| Protein, total (g/dL) | 2-3                                                                              | 2.5-3.5                                          | 2.4-4.1                                                          |
| Albumin (g/dL)        | —                                                                                | 1.8-2.5                                          | 0.7-1.8                                                          |
| Globulin (g/dL)       | —                                                                                | 0.9-1.7                                          | —                                                                |

| Measurement       | Budgerigar<br>Parakeet ( <i>Melopsittacus undulatus</i> ) <sup>172,180,218</sup> | Caique<br>( <i>Pionites</i> spp.) <sup>173</sup> | Cockatiel ( <i>Nymphicus hollandicus</i> ) <sup>18,173,218</sup> |
|-------------------|----------------------------------------------------------------------------------|--------------------------------------------------|------------------------------------------------------------------|
| A:G ratio         | —                                                                                | 1.7-2.8                                          | 1.5-4.3                                                          |
| Prealbumin (g/dL) | —                                                                                | —                                                | 0.8-1.6                                                          |
| α-globulin (g/dL) | —                                                                                | —                                                | 0.05-0.4 (α <sub>1</sub> )                                       |
|                   | —                                                                                | —                                                | 0.05-0.44 (α <sub>2</sub> )                                      |
| β-globulin (g/dL) | —                                                                                | —                                                | 0.21-0.58                                                        |
| γ-globulin (g/dL) | —                                                                                | —                                                | 0.11-0.43                                                        |
| Sodium (mEq/L)    | 139-159                                                                          | —                                                | 132-150                                                          |
| Uric acid (mg/dL) | 3-8.6                                                                            | 2.5-10.7                                         | 3.5-11                                                           |

|             |                                  |                            | Eclectus Parrot<br>( <i>Eclectus roratus</i> ) <sup>138,173,218</sup> |
|-------------|----------------------------------|----------------------------|-----------------------------------------------------------------------|
| Measurement | Cockatoos <sup>138,173,218</sup> | Conures <sup>173,218</sup> |                                                                       |

Hematology

|                           |         |         |         |
|---------------------------|---------|---------|---------|
| PCV (%)                   | 42-54   | 42-54   | 45-55   |
| RBC (10 <sup>6</sup> /μL) | 2-4     | 2.9-4.5 | 2.7-3.8 |
| Hgb (g/dL)                | 12-16   | 12-16   | 13.5-16 |
| MCV (fL)                  | 120-175 | 90-190  | 125-175 |
| MCH (pg)                  | 35-55   | 28-55   | 40-50   |
| MCHC (g/dL)               | 28-33   | 23-31   | 29-32   |
| WBC (10 <sup>3</sup> /μL) | 5-13    | 4-13    | 9-20    |
| Heterophils (%)           | 15-64   | 40-70   | 35-50   |
| Lymphocytes (%)           | 29-83   | 20-50   | 45-65   |
| Monocytes (%)             | 0-9     | 0-3     | 1-7     |
| Eosinophils (%)           | 0       | 0-3     | 1       |
| Basophils (%)             | 0-3     | 0-5     | 0-3     |
| H:L ratio                 | 0-2     | 0.8-3.8 | 1-2     |

Chemistries

|           |        |        |        |
|-----------|--------|--------|--------|
| ALP (U/L) | 24-104 | 24-250 | 32-111 |
| ALT (U/L) | 0-5    | 5-13   | 0-5    |

Continued

| Measurement           | Cockatoos <sup>138,273,272</sup> | Conures <sup>272,278</sup>  | Eclectus Parrot<br>( <i>Eclectus roratus</i> ) <sup>138,273,278</sup> |
|-----------------------|----------------------------------|-----------------------------|-----------------------------------------------------------------------|
| Amylase (U/L)         | 200-876                          | 192-954                     | 562-684                                                               |
| AST (U/L)             | 120-360                          | 125-378                     | 135-339                                                               |
| Bile acid (μmol/L)    |                                  |                             |                                                                       |
| RIA                   | 20-70                            | 20-45                       | —                                                                     |
| Colorimetric          | 34-112                           | 32-105                      | 30-110                                                                |
| Calcium (mg/dL)       | 8-11                             | 8-15                        | 8.8-9.8                                                               |
| Chloride (mEq/L)      | 110-120                          | —                           | 112-120                                                               |
| Cholesterol (mg/dL)   | 150-300                          | 120-400                     | 220-325                                                               |
| CK (U/L)              | 140-410                          | 35-355                      | 132-625                                                               |
| Creatinine (mg/dL)    | 0.2-0.7                          | 0.1-0.5                     | 0.4-0.5                                                               |
| GGT (U/L)             | 0-4                              | 1-15                        | 1-5                                                                   |
| Glucose (mg/dL)       | 200-300                          | 200-350                     | 225-300                                                               |
| LDH (U/L)             | 150-1000                         | 125-420                     | 100-386                                                               |
| Phosphorus (mg/dL)    | 3.5-6.5                          | 2-10                        | 4.5-7                                                                 |
| Potassium (mEq/L)     | 3-5                              | 3.4-5                       | 2.2-4.6                                                               |
| Protein, total (g/dL) | 3-5                              | 2.5-4.5                     | 4-5                                                                   |
| Albumin (g/dL)        | 1-1.6                            | 1.9-2.6                     | 1.4-1.8                                                               |
| Globulin (g/dL)       | 1.5-2.5                          | —                           | 1.3-2.3                                                               |
| A:G ratio             | 0.6-2.4                          | 2.2-4.3                     | 0.52-1.79                                                             |
| Pre-albumin (g/dL)    | 0.3-0.6                          | 0.18-0.98                   | —                                                                     |
| α-globulin (g/dL)     | 0.1-0.5                          | 0.04-0.23 (α <sub>1</sub> ) | 0.6-1.2                                                               |
|                       | —                                | 0.08-0.26 (α <sub>2</sub> ) | —                                                                     |
| β-globulin (g/dL)     | 0.2-0.4                          | 0.07-0.47                   | 0.6-1.2                                                               |
| γ-globulin (g/dL)     | 0.5                              | 0.12-0.61                   | 0.6-1.2                                                               |
| Sodium (mEq/L)        | 145-155                          | 134-148                     | 150-158                                                               |
| Uric acid (mg/dL)     | 2-8.5                            | 2.5-10.5                    | 0.7-5                                                                 |

| Measurement | Grey-Cheeked Parakeet ( <i>Broto geris pyrrhoptera</i> ) <sup>140</sup> | Jardine's Parrot ( <i>Poicephalus gulielmi</i> ) <sup>118</sup> | Lory ( <i>Eos spp</i> ) <sup>171, 727, 818</sup> |
|-------------|-------------------------------------------------------------------------|-----------------------------------------------------------------|--------------------------------------------------|
|-------------|-------------------------------------------------------------------------|-----------------------------------------------------------------|--------------------------------------------------|

Hematology

|                           |        |        |           |
|---------------------------|--------|--------|-----------|
| PCV (%)                   | 45-58  | 35-48  | 47-55     |
| RBC (10 <sup>6</sup> /μL) | —      | 2.4-4  | 3.3-4     |
| Hgb (g/dL)                | —      | 11-16  | 10.8-14.8 |
| MCV (fL)                  | —      | 90-190 | 28-31     |
| MCH (pg)                  | —      | 25-56  | —         |
| MCHC (g/dL)               | —      | 21-33  | 21-23     |
| WBC (10 <sup>3</sup> /μL) | 4.5-12 | 4-10   | 8-13      |
| Heterophils (%)           | 40-75  | 55-75  | 40-60     |
| Lymphocytes (%)           | 20-60  | 25-45  | 22-69     |
| Monocytes (%)             | 0-3    | 0-2    | 0-2       |
| Eosinophils (%)           | 0-1    | 0-1    | 0-1       |
| Basophils (%)             | 0-5    | 0-1    | 0-1       |
| H:L ratio                 | —      | 1.2-3  | —         |

Chemistries

|                     |         |         |         |
|---------------------|---------|---------|---------|
| ALP (U/L)           | —       | —       | —       |
| ALT (U/L)           | —       | —       | —       |
| Amylase (U/L)       | —       | 100-425 | 20-65   |
| AST (U/L)           | 150-388 | 150-275 | 141-369 |
| Bile acid (μmol/L)  |         |         |         |
| RIA                 | —       | 25-65   | 20-65   |
| Colorimetric        | 15-96   | —       | 20-97   |
| Calcium (mg/dL)     | —       | —       | 8-12    |
| Chloride (mEq/L)    | 0.1-0.4 | 7-13    | —       |
| Cholesterol (mg/dL) | —       | —       | 100-257 |
| CK (U/L)            | —       | —       | 178-396 |
| Creatinine (mg/dL)  | —       | —       | —       |

Continued

| Measurement           | Grey-Cheeked Parakeet ( <i>Brotogeris pyrrhoptera</i> ) <sup>140</sup> | Jardine's Parrot ( <i>Poicephalus gulielmi</i> ) <sup>118</sup> | Lory ( <i>Eos spp</i> ) <sup>171, 227, 218</sup> |
|-----------------------|------------------------------------------------------------------------|-----------------------------------------------------------------|--------------------------------------------------|
| GGT (U/L)             | —                                                                      | —                                                               | —                                                |
| Glucose (mg/dL)       | 200-350                                                                | 200-325                                                         | 200-400                                          |
| LDH (U/L)             | 150-450                                                                | —                                                               | 124-302                                          |
| Phosphorus (mg/dL)    | —                                                                      | —                                                               | —                                                |
| Potassium (mEq/L)     | —                                                                      | —                                                               | —                                                |
| Protein, total (g/dL) | 2.5-4.5                                                                | 2.8-4                                                           | 1.9-4.1                                          |
| Albumin (g/dL)        | —                                                                      | —                                                               | 1.3-2.1                                          |
| Globulin (g/dL)       | —                                                                      | —                                                               | 0.9-2.4                                          |
| A:G ratio             | —                                                                      | —                                                               | 1-2.3                                            |
| Prealbumin (g/dL)     | —                                                                      | —                                                               | —                                                |
| α-globulin (g/dL)     | —                                                                      | —                                                               | —                                                |
| β-globulin (g/dL)     | —                                                                      | —                                                               | —                                                |
| γ-globulin (g/dL)     | —                                                                      | —                                                               | —                                                |
| Sodium (mEq/L)        | —                                                                      | —                                                               | —                                                |
| Uric acid (mg/dL)     | 4-12                                                                   | 2.5-12                                                          | 2-11.9                                           |

| Measurement | Lovebird ( <i>Agapornis spp</i> ) <sup>173, 218</sup> | Macaw ( <i>Ara spp</i> ) <sup>131, 136, 273, 218</sup> | Pionus Parrots ( <i>Pionus spp</i> ) <sup>173, 218</sup> |
|-------------|-------------------------------------------------------|--------------------------------------------------------|----------------------------------------------------------|
|-------------|-------------------------------------------------------|--------------------------------------------------------|----------------------------------------------------------|

|                           |        |         |        |
|---------------------------|--------|---------|--------|
| Hematology                |        |         |        |
| PCV (%)                   | 44-57  | 47-55   | 35-54  |
| RBC (10 <sup>6</sup> /μL) | 3-5.1  | 2.7-4.5 | 2.4-4  |
| Hgb (g/dL)                | 13-18  | 15-17   | 11-16  |
| MCV (fL)                  | 90-190 | 125-170 | 85-210 |
| MCH (pg)                  | 27-59  | 36-55   | 26-54  |
| MCHC (g/dL)               | 22-32  | 29-35   | 24-31  |



| Measurement               | Lovebird<br>( <i>Agapornis</i> spp) <sup>373,918</sup> | Macaw<br>( <i>Ara</i> spp) <sup>103,139,273,918</sup> | Pionus Parrots<br>( <i>Pionus</i> spp) <sup>373,918</sup> |
|---------------------------|--------------------------------------------------------|-------------------------------------------------------|-----------------------------------------------------------|
| WBC (10 <sup>3</sup> /μL) | 3-16                                                   | 7-22                                                  | 4-11.5                                                    |
| Heterophils (%)           | 40-75                                                  | 40-60                                                 | 50-75                                                     |
| Lymphocytes (%)           | 20-55                                                  | 35-60                                                 | 25-45                                                     |
| Monocytes (%)             | 0-2                                                    | 1-8                                                   | 0-2                                                       |
| Eosinophils (%)           | 0-1                                                    | 0-1                                                   | 0-2                                                       |
| Basophils (%)             | 0-6                                                    | 0-1                                                   | 0-1                                                       |
| H:L ratio                 | 0.7-3.8                                                | 0.6-1.8                                               | 1.1-3                                                     |
| <b>Chemistries</b>        |                                                        |                                                       |                                                           |
| ALP (U/L)                 | 10-90                                                  | 290-750                                               | 12-100                                                    |
| ALT (U/L)                 | —                                                      | 0-5                                                   | —                                                         |
| Amylase (U/L)             | 90-400                                                 | 239-564                                               | 200-500                                                   |
| AST (U/L)                 | 100-360                                                | 90-180                                                | 135-365                                                   |
| Bile acid (μmol/L)        |                                                        |                                                       |                                                           |
| RIA                       | 25-95                                                  | 6-35                                                  | 14-60                                                     |
| Colorimetric              | 12-90                                                  | 7-100                                                 | 15-92                                                     |
| Calcium (mg/dL)           | 9-15                                                   | 9.5-10.5                                              | 7-13.5                                                    |
| Chloride (mEq/L)          | —                                                      | 105-113                                               | —                                                         |
| Cholesterol (mg/dL)       | 95-335                                                 | 100-300                                               | 130-295                                                   |
| CK (U/L)                  | 52-245                                                 | 180-500                                               | —                                                         |
| Creatinine (mg/dL)        | 0.1-0.4                                                | 0.5-0.6                                               | 0.1-0.4                                                   |
| GGT (U/L)                 | 2.5-18                                                 | 0-4                                                   | —                                                         |
| Glucose (mg/dL)           | 200-400                                                | 280-320                                               | 125-300                                                   |
| LDH (U/L)                 | 100-350                                                | 40-250                                                | —                                                         |
| Phosphorus (mg/dL)        | 3.2-4.9                                                | 4.6-6.4                                               | 2.9-6.6                                                   |
| Potassium (mEq/L)         | 2.5-3.5                                                | 2.2-3.9                                               | 3.5-4.6                                                   |
| Protein, total (g/dL)     | 2.4-4.6                                                | 3.4-4.2                                               | 3.2-4.6                                                   |

Continued

| Measurement       | Lovebird<br>( <i>Agapornis</i> spp) <sup>273, 318</sup> | Macaw<br>( <i>Ara</i> spp) <sup>102, 139, 273, 318</sup> | Pionus Parrots<br>( <i>Pionus</i> spp) <sup>273, 318</sup> |
|-------------------|---------------------------------------------------------|----------------------------------------------------------|------------------------------------------------------------|
| Albumin (g/dL)    | —                                                       | 1.3-1.7                                                  | —                                                          |
| Globulin (g/dL)   | —                                                       | 1.3-1.9                                                  | —                                                          |
| A:G ratio         | 0.8-2                                                   | 0.7-1                                                    | 0.6-1.9                                                    |
| Prealbumin (g/dL) | —                                                       | 0.3-0.6                                                  | —                                                          |
| α-globulin (g/dL) | —                                                       | 0.1-0.4                                                  | —                                                          |
| β-globulin (g/dL) | —                                                       | 0.2-0.6                                                  | —                                                          |
| γ-globulin (g/dL) | —                                                       | 0.2-0.4                                                  | —                                                          |
| Sodium (mEq/L)    | 137-150                                                 | 148-156                                                  | 145-155                                                    |
| Uric acid (mg/dL) | 3-11                                                    | 1-6                                                      | 3.5-10                                                     |

| Measurement | Quaker Parakeet ( <i>Myopsitta monachus</i> ) <sup>273, 281, 318</sup> | Senegal Parrot ( <i>Poicephalus senegalus</i> ) <sup>273, 318</sup> |
|-------------|------------------------------------------------------------------------|---------------------------------------------------------------------|
|-------------|------------------------------------------------------------------------|---------------------------------------------------------------------|

|                           |         |        |
|---------------------------|---------|--------|
| Hematology                |         |        |
| PCV (%)                   | 30-58   | 36-48  |
| RBC (10 <sup>6</sup> /μL) | 2.8-3.9 | 2.4-4  |
| Hgb (g/dL)                | 11-15   | 11-16  |
| MCV (fL)                  | 90-200  | 90-200 |
| MCH (pg)                  | 26-55   | 27-55  |
| MCHC (g/dL)               | 22-32   | 23-32  |
| WBC (10 <sup>3</sup> /μL) | 8-17    | 4-14   |
| Heterophils (%)           | 0-24    | 55-75  |
| Lymphocytes (%)           | 74-90   | 25-45  |
| Monocytes (%)             | 1-4     | 0-2    |
| Eosinophils (%)           | 0-2     | 0-1    |
| Basophils (%)             | 0-6     | 0-1    |
| H:L ratio                 | —       | 1.2-3  |



| Measurement           | Quaker Parakeet ( <i>Myopsitta monachus</i> ) <sup>100,101,102</sup> | Senegal Parrot ( <i>Poicephalus senegalus</i> ) <sup>101,102</sup> |
|-----------------------|----------------------------------------------------------------------|--------------------------------------------------------------------|
| <b>Chemistries</b>    |                                                                      |                                                                    |
| ALP (U/L)             | 70-300                                                               | 70-300                                                             |
| ALT (U/L)             | 5-11                                                                 | 5-11                                                               |
| Amylase (U/L)         | 100-400                                                              | 190-550                                                            |
| AST (U/L)             | 150-380                                                              | 120-330                                                            |
| Bile acid (μmol/L)    |                                                                      |                                                                    |
| RIA                   | 25-65                                                                | 20-85                                                              |
| Colorimetric          | 21-90                                                                | 20-94                                                              |
| Calcium (mg/dL)       | 7-12                                                                 | 6.5-13                                                             |
| Chloride (mEq/L)      | —                                                                    | —                                                                  |
| Cholesterol (mg/dL)   | 100-295                                                              | 130-340                                                            |
| CK (U/L)              | 110-320                                                              | 100-330                                                            |
| Creatinine (mg/dL)    | 0.1-0.4                                                              | 0.1-0.4                                                            |
| GGT (U/L)             | 1-15                                                                 | 1-15                                                               |
| Glucose (mg/dL)       | 200-350                                                              | 140-250                                                            |
| LDH (U/L)             | 120-300                                                              | 150-350                                                            |
| Phosphorus (mg/dL)    | 2.9-6.5                                                              | 2.5-9.5                                                            |
| Potassium (mEq/L)     | 2.8-4.6                                                              | 3-5                                                                |
| Protein, total (g/dL) | 3.8-5                                                                | 3-4.5                                                              |
| Albumin (g/dL)        | 1.26-2.52                                                            | 1.45-2.23                                                          |
| Globulin (g/dL)       | —                                                                    | —                                                                  |
| A:G ratio             | 0.7-1.8                                                              | 2.2-3.9                                                            |
| Prealbumin (g/dL)     | 0.48-1.13                                                            | 0.19-0.64                                                          |
| α-globulin (g/dL)     | —                                                                    | —                                                                  |
| β-globulin (g/dL)     | 0.41-0.63                                                            | 0.36-0.58                                                          |
| γ-globulin (g/dL)     | 0.13-0.48                                                            | 0.14-0.23                                                          |
| Sodium (mEq/L)        | 140-155                                                              | 130-155                                                            |
| Uric acid (mg/dL)     | 3.5-11.5                                                             | 2.3-10                                                             |

<sup>a</sup>Hematologically, psittacines are a very homogenous group with similar RBC parameters: PCV 35-55%, RBC count of 2.4-5 x10<sup>6</sup>/μL; hemoglobin concentration of 11-16 g/dL; MCV of 90-200 fL; MCHC of 22-33 g/dL, and H:L ratio ranging 1.1-2.4 (average 1.7).<sup>100,102</sup>

TABLE 5-20 Hematologic and Serum Biochemical Values for Juveniles of Selected Psittaciformes.

| Measurement               | Mean ± SD (Range)                                                                   |                                                                                  |                                                                              |                                                                                   |                                                                                  |
|---------------------------|-------------------------------------------------------------------------------------|----------------------------------------------------------------------------------|------------------------------------------------------------------------------|-----------------------------------------------------------------------------------|----------------------------------------------------------------------------------|
|                           | Cockatoos ( <i>Cacatua</i> spp.) <sup>1</sup> (9 species)<br>(n = 152) <sup>a</sup> | Umbrella Cockatoo ( <i>Cacatua alba</i> ) <sup>2</sup><br>(n = 111) <sup>a</sup> | Macaws ( <i>Ara</i> spp.) <sup>3</sup> (7 species)<br>(n = 113) <sup>a</sup> | Blue and Gold Macaw ( <i>Ara ararauna</i> ) <sup>4</sup><br>(n = 43) <sup>a</sup> | Eclectus Parrots ( <i>Eclectus roratus</i> ) <sup>5</sup> (n = 111) <sup>a</sup> |
| <b>Hematology</b>         |                                                                                     |                                                                                  |                                                                              |                                                                                   |                                                                                  |
| PCV (%)                   | 39.7 ± 9 (25-59)                                                                    | 39.3                                                                             | 41.7 ± 8.4 (25-55)                                                           | 40 ± 7.7                                                                          | 43.8 ± 8.4 (26-58)                                                               |
| RBC (10 <sup>6</sup> /μL) | 2.53 ± 0.63 (1.5-4)                                                                 | 2.54                                                                             | 2.9 ± 0.8 (1.5-4.5)                                                          | 2.7 ± 0.7                                                                         | 2.69 ± 0.67 (1.5-4)                                                              |
| Hgb (g/dL)                | 11.4 ± 2.9 (6.5-17)                                                                 | 11.6                                                                             | 12.3 ± 3.3 (7-17)                                                            | 11 ± 2.9                                                                          | 12.5 ± 3 (6.5-18)                                                                |
| WBC (10 <sup>3</sup> /μL) | 12.9 ± 6.3 (5.5-25)                                                                 | 16.6                                                                             | 19.2 ± 6.9 (7-30)                                                            | 18.9 ± 5.6                                                                        | 13.7 ± 6.3 (5.5-25)                                                              |
| Heterophils (%)           | 50.8 ± 11.7 (27-74)                                                                 | 54.1                                                                             | 55.3 ± 10 (37-75)                                                            | 52 ± 10                                                                           | 53.9 ± 11.4 (35-75)                                                              |
| Bands (%)                 | 1.3 ± 2.3 (0-7)                                                                     | 1.31                                                                             | 0.6 ± 1.7 (0-5)                                                              | 0.1 ± 0.7                                                                         | 0.5 ± 1.5 (0-5)                                                                  |
| Lymphocytes (%)           | 41.2 ± 11.9 (17-65)                                                                 | 38.1                                                                             | 39 ± 10 (20-60)                                                              | 42 ± 10                                                                           | 39.5 ± 11.5 (20-65)                                                              |
| Monocytes (%)             | 5.8 ± 3.4 (0-12)                                                                    | 5.35                                                                             | 4.4 ± 2.9 (1-10)                                                             | 4.3 ± 2.7                                                                         | 5 ± 2.7 (1-11)                                                                   |
| Eosinophils (%)           | 0                                                                                   | 0.02                                                                             | 0 ± 0.2 (0-1)                                                                | 0                                                                                 | 0.1 ± 0.3 (0-1)                                                                  |
| Basophils (%)             | 0.9 ± 1.1 (0-4)                                                                     | 1.03                                                                             | 0.5 ± 1 (0-3)                                                                | 0.9 ± 1.3                                                                         | 1.1 ± 1 (0-3)                                                                    |
| <b>Chemistries</b>        |                                                                                     |                                                                                  |                                                                              |                                                                                   |                                                                                  |
| ALP (U/L)                 | 579 ± 239 (200-1000)                                                                | 440                                                                              | 970 ± 397 (290-1600)                                                         | 1200 ± 390                                                                        | 489 ± 159 (200-900)                                                              |
| ALT (U/L)                 | 2 ± 3 (0-13)                                                                        | 2.1                                                                              | 3 ± 2 (0-9)                                                                  | 4 ± 3                                                                             | 4 ± 3 (0-10)                                                                     |
| AST (U/L)                 | 143 ± 79 (50-400)                                                                   | 136                                                                              | 104 ± 31 (60-180)                                                            | 101 ± 24                                                                          | 140 ± 58 (65-260)                                                                |
| BUN (mg/dL)               | 2 ± 2.2 (0-6)                                                                       | 1.6                                                                              | 2.4 ± 2.3 (0-6)                                                              | 1.9 ± 2.2                                                                         | 1.7 ± 2.4 (0-6)                                                                  |
| Calcium (mg/dL)           | 9.6 ± 0.7 (8-11)                                                                    | 9.8                                                                              | 9.9 ± 0.5 (8.5-10.8)                                                         | 10 ± 0.5                                                                          | 9.3 ± 0.4 (8.5-10.2)                                                             |
| Chloride (mEq/L)          | 110 ± 6 (97-120)                                                                    | 111                                                                              | 106 ± 6 (96-118)                                                             | 104 ± 5                                                                           | 111 ± 5 (100-120)                                                                |
| Cholesterol (mg/dL)       | 251 ± 105 (100-500)                                                                 | 291                                                                              | 165 ± 62 (75-300)                                                            | 164 ± 67                                                                          | 268 ± 80 (125-450)                                                               |
| CK (U/L)                  | 510 ± 235 (140-1000)                                                                | 517                                                                              | 550 ± 312 (180-1100)                                                         | 540 ± 267                                                                         | 616 ± 472 (200-1600)                                                             |
| Creatinine (mg/dL)        | 0.4 ± 0.1 (0.2-0.7)                                                                 | 0.4                                                                              | 0.4 ± 0.1 (0.3-0.6)                                                          | 0.4 ± 0.1                                                                         | 0.4 ± 0.1 (0.2-0.5)                                                              |

Continued

| Measurement | Mean ± SD (range)                                                     |                                                                     |                                                                |                                                                      |                                                                     |
|-------------|-----------------------------------------------------------------------|---------------------------------------------------------------------|----------------------------------------------------------------|----------------------------------------------------------------------|---------------------------------------------------------------------|
|             | Cockatoos ( <i>Cacatua</i> spp) <sup>1</sup> (9 species)<br>(n = 152) | Umbrella Cockatoo ( <i>Cacatua alba</i> ) <sup>1</sup><br>(n = 111) | Macaws ( <i>Ara</i> spp) <sup>1</sup> (7 species)<br>(n = 113) | Blue and Gold Macaw ( <i>Ara ararauna</i> ) <sup>1</sup><br>(n = 43) | Eclectus Parrots ( <i>Eclectus roratus</i> ) <sup>1</sup> (n = 111) |

Chemistries (cont'd)

|                       |                      |     |                     |           |                     |
|-----------------------|----------------------|-----|---------------------|-----------|---------------------|
| GGT (U/L)             | 2.6 ± 1.7 (0-6)      | 2.7 | 1.8 ± 1.2 (0-4)     | 1.7 ± 1.2 | 4 ± 2 (0-7)         |
| Glucose (mg/dL)       | 253 ± 24 (200-300)   | 244 | 281 ± 30 (225-330)  | 288 ± 31  | 258 ± 18 (220-300)  |
| LDH (U/L)             | 371 ± 285 (150-1000) | 325 | 138 ± 84 (35-275)   | 144 ± 98  | 228 ± 101 (100-400) |
| Phosphorus (mg/dL)    | 6.1 ± 1.1 (3.5-8)    | 5.6 | 6.5 ± 1 (4.6-6.9)   | 6.6 ± 0.9 | 6.8 ± 1.2 (4.5-9)   |
| Potassium (mEq/L)     | 3.6 ± 0.7 (2.5-5.5)  | 3.5 | 2.9 ± 0.8 (2-4.2)   | 2.7 ± 0.6 | 2.8 ± 0.7 (2-4.6)   |
| Protein, total (g/dL) | 2.8 ± 0.7 (1.5-4)    | 3   | 2.6 ± 0.6 (1.5-3.5) | 2.5 ± 0.7 | 2.9 ± 0.5 (1.8-3.8) |
| Albumin (g/dL)        | 1.1 ± 0.3 (0.3-1.6)  | 1.7 | 1.2 ± 0.3 (0.6-1.7) | 1.2 ± 0.3 | 1.3 ± 0.3 (0.8-1.8) |
| Globulin (g/dL)       | 1.7 ± 0.5 (0.8-2.5)  | 0.9 | 1.3 ± 0.6 (0.8-1.9) | 1.3 ± 0.6 | 1.5 ± 0.3 (0.8-2.2) |
| A:G ratio             | 0.6 ± 0.2 (0.4-1)    | 0.6 | 0.8 ± 0.3 (0.5-1)   | 0.8 ± 0.2 | 0.9 ± 0.2 (0.6-1.1) |
| Sodium (mEq/L)        | 145 ± 6 (135-155)    | 145 | 145 ± 6 (135-156)   | 142 ± 6   | 148 ± 6 (138-158)   |
| Uric acid (mg/dL)     | 2.9 ± 2.3 (0.2-8.5)  | 2.7 | 2.3 ± 2.1 (0.2-6)   | 1.9 ± 2.5 | 2 ± 1.6 (0.2-6.5)   |

<sup>1</sup>n = number of blood samples (multiple blood samples were obtained from some individuals over time).

TABLE 5-21 Hematologic and Serum Biochemical Values of Selected Passeriformes.

| Measurement | Canary ( <i>Serinus canaria</i> ) <sup>187,218</sup> | Finch <sup>140</sup> | Mynah ( <i>Gracula religiosa</i> ) <sup>13</sup> |
|-------------|------------------------------------------------------|----------------------|--------------------------------------------------|
|-------------|------------------------------------------------------|----------------------|--------------------------------------------------|

Hematology

|                           |         |         |            |
|---------------------------|---------|---------|------------|
| PCV (%)                   | 37-49   | 45-62   | 47.6 ± 4.9 |
| RBC (10 <sup>6</sup> /μL) | 2.5-3.8 | 2.5-4.6 | 3.8 ± 0.4  |
| Hgb (g/dL)                | 12-16   | —       | 14.3 ± 1.2 |
| MCV (fL)                  | 90-210  | —       | 126 ± 11.7 |
| MCH (pg)                  | 26-55   | —       | 38.4 ± 3.6 |
| MCHC (g/dL)               | 22-32   | —       | 30.1 ± 1.5 |
| WBC (10 <sup>3</sup> /μL) | 4-9     | 3-8     | 20.8 ± 5.8 |
| Heterophils (%)           | 50-80   | 20-65   | 43.8 ± 8   |
| Lymphocytes (%)           | 20-45   | 20-65   | 48.7 ± 7.5 |
| Monocytes (%)             | 0-1     | 0-1     | 4.6 ± 4.1  |
| Eosinophils (%)           | 0-2     | 0-1     | 4.1 ± 2.5  |
| Basophils (%)             | 0-1     | 0-5     | 0.8 ± 0.7  |
| H:L ratio                 | —       | 0.3-3.3 | —          |

## Chemistries

|                     |          |         |         |
|---------------------|----------|---------|---------|
| ALP (U/L)           | 20-135   | —       | —       |
| ALT (U/L)           | —        | —       | —       |
| AST (U/L)           | 145-345  | 150-350 | 130-350 |
| Bile acid (μmol/L)  |          |         |         |
| RIA                 | 23-90    | —       | —       |
| Colorimetric        | —        | —       | —       |
| Calcium (mg/dL)     | 5.5-13.5 | —       | 9-13    |
| Chloride (mEq/L)    | —        | —       | —       |
| Cholesterol (mg/dL) | 150-400  | —       | —       |
| CK (U/L)            | 55-350   | —       | —       |
| Creatinine (mg/dL)  | 0.1-0.4  | —       | 0.1-0.6 |
| GGT (U/L)           | 1-14     | —       | —       |
| Glucose (mg/dL)     | 205-435  | 200-450 | 190-350 |

*Continued*

| Measurement           | Canary ( <i>Serinus canaria</i> ) <sup>107, 118</sup> | Finch <sup>140</sup> | Mynah ( <i>Gracula religiosa</i> ) <sup>11</sup> |
|-----------------------|-------------------------------------------------------|----------------------|--------------------------------------------------|
| LDH (U/L)             | 120-450                                               | —                    | 600-1000                                         |
| Phosphorus (mg/dL)    | 2.9-4.9                                               | —                    | —                                                |
| Potassium (mEq/L)     | 2.2-4.5                                               | —                    | 0.3-5.1                                          |
| Protein, total (g/dL) | 2.8-4.5                                               | 3-5                  | 2.3-4.5                                          |
| Albumin (g/dL)        | —                                                     | —                    | —                                                |
| Globulin (g/dL)       | —                                                     | —                    | —                                                |
| A:G ratio             | —                                                     | —                    | —                                                |
| Sodium (mEq/L)        | 135-165                                               | —                    | 136-152                                          |
| Uric acid (mg/dL)     | 4-12                                                  | 4-12                 | 4-10                                             |

\*Values reported in captive adult males.

TABLE 5-22 Hematologic and Serum Biochemical Values of Selected Galliformes.

| Measurement               | Chicken<br>( <i>Gallus gallus</i> ) <sup>187</sup> | Quail<br>( <i>Coturnix</i> spp) <sup>187, 273</sup> | Ring-Necked<br>Pheasant ( <i>Phasianus colchicus</i> ) <sup>118, 277</sup> | Turkey<br>( <i>Meleagris gallopavo</i> ) <sup>187</sup> |
|---------------------------|----------------------------------------------------|-----------------------------------------------------|----------------------------------------------------------------------------|---------------------------------------------------------|
| <b>Hematology</b>         |                                                    |                                                     |                                                                            |                                                         |
| PCV (%)                   | 23-55                                              | 30-45.1                                             | —                                                                          | 30.4-45.6                                               |
| RBC (10 <sup>6</sup> /μL) | 1.3-4.5                                            | 4-5.2                                               | 1.2-3.5                                                                    | 1.74-3.7                                                |
| Hgb (g/dL)                | 7-18.6                                             | 10.7-14.3                                           | 8-11.2                                                                     | 8.8-13.4                                                |
| MCV (fL)                  | 100-139                                            | 60-100                                              | —                                                                          | 112-168                                                 |
| MCH (pg)                  | 25-48                                              | 23-35                                               | —                                                                          | 32-49.3                                                 |
| MCHC (g/dL)               | 20-34                                              | 28-38.5                                             | —                                                                          | 23.2-35.3                                               |
| WBC (10 <sup>3</sup> /μL) | 9-32                                               | 12.5-24.6                                           | 18-39                                                                      | 16-25.5                                                 |
| Heterophils (%)           | 15-50                                              | 25-50                                               | 12-30                                                                      | 29-52                                                   |
| Lymphocytes (%)           | 29-84                                              | 50-70                                               | 63-83                                                                      | 35-48                                                   |
| Monocytes (%)             | 0.1-7                                              | 0.5-3.8                                             | 2-9                                                                        | 3-10                                                    |
| Eosinophils (%)           | 0-16                                               | 0-15                                                | 0                                                                          | 0-5                                                     |
| Basophils (%)             | 0-8                                                | 0-1.5                                               | 0-3                                                                        | 1-9                                                     |
| H:L ratio                 | 0.2-1.7                                            | 0.4-1                                               | 0.14-0.48                                                                  | 0.6-1.5                                                 |
| <b>Chemistries</b>        |                                                    |                                                     |                                                                            |                                                         |
| ALT (U/L)                 | —                                                  | 6.5-9.6                                             | —                                                                          | —                                                       |
| AST (U/L)                 | —                                                  | 402-422                                             | —                                                                          | —                                                       |
| Calcium (mg/dL)           | 13.2-23.7                                          | —                                                   | —                                                                          | 11.7-38.7                                               |
| Cholesterol (mg/dL)       | 86-211                                             | —                                                   | —                                                                          | 81-129                                                  |
| Creatinine (mg/dL)        | 0.9-1.8                                            | 0.05                                                | —                                                                          | 0.8-0.9                                                 |
| GGT (U/L)                 | —                                                  | 1.7-1.9                                             | —                                                                          | —                                                       |
| Glucose (mg/dL)           | 227-300                                            | 259-312                                             | —                                                                          | 275-425                                                 |
| Phosphorus (mg/dL)        | 6.2-7.9                                            | —                                                   | —                                                                          | 5.4-7.1                                                 |
| Potassium (mEq/L)         | 3-7.3                                              | 1.4                                                 | —                                                                          | 6-6.4                                                   |
| Protein, total (g/dL)     | 3.3-5.5                                            | 3.4-3.6                                             | 4.5-5.1                                                                    | 4.9-7.6                                                 |
| Albumin (g/dL)            | 1.3-2.8                                            | 1.3-1.5                                             | 2.6-2.7                                                                    | 3-5.9                                                   |
| Globulin (g/dL)           | 1.5-4.1                                            | —                                                   | 1.9-2.1                                                                    | 1.7-1.9                                                 |
| Sodium (mEq/L)            | 131-171                                            | 180                                                 | —                                                                          | 149-155                                                 |
| Uric acid (mg/dL)         | 2.5-8.1                                            | 5.4-5.5                                             | 5.6-6                                                                      | 3.4-5.2                                                 |

<sup>a</sup>Except for phosphorus, protein (total), and sodium, biochemistry values are reported in 16-week-old Japanese quail.

TABLE 5-23 Hematologic and Serum Biochemical Values of Selected Anseriformes (Waterfowl).

| Measurement | Canada Goose ( <i>Branta canadensis</i> ) <sup>107,108</sup> | Mallard Duck ( <i>Anas platyrhynchos</i> ) <sup>107</sup> | Wood Duck ( <i>Aix sponsa</i> ) <sup>107</sup> |
|-------------|--------------------------------------------------------------|-----------------------------------------------------------|------------------------------------------------|
|-------------|--------------------------------------------------------------|-----------------------------------------------------------|------------------------------------------------|

Hematology

|                           |           |           |            |
|---------------------------|-----------|-----------|------------|
| PCV (%)                   | 38-58     | 39-49     | 45.5 ± 3.4 |
| RBC (10 <sup>6</sup> /μL) | 1.6-2.7   | 2-3.8     | 2.8 ± 0.2  |
| Hgb (g/dL)                | 12.7-19.1 | 7.4-15.6  | 15 ± 1     |
| MCV (fL)                  | 145-210   | 148-200   | 164 ± 14   |
| MCH (pg)                  | 53.7-70   | —         | —          |
| MCHC (g/dL)               | 28-32     | 29-32     | 33 ± 4     |
| WBC (10 <sup>3</sup> /μL) | 13-21.8   | 23.4-24.8 | 25.6 ± 5.7 |
| Heterophils (%)           | 39        | 26-38     | —          |
| Lymphocytes (%)           | 46        | 54-63     | —          |
| Monocytes (%)             | 6         | 1-4       | —          |
| Eosinophils (%)           | 2         | 0.2-0.4   | —          |
| Basophils (%)             | 7         | 0-4       | —          |
| H:L ratio                 | 0.5-0.9   | 0.4-2     | 0.4-0.7    |

Chemistries

|                     |            |   |          |
|---------------------|------------|---|----------|
| ALP (U/L)           | 72 ± 43    | — | 160-780  |
| ALT (U/L)           | 43 ± 11    | — | 19-48    |
| AST (U/L)           | 75 ± 17    | — | 45-123   |
| Bile acid (μmol/L)  |            |   |          |
| RIA                 | —          | — | 22-60    |
| Colorimetric        | —          | — | —        |
| Calcium (mg/dL)     | 10.2 ± 0.7 | — | 7.6-10.4 |
| Chloride (mEq/L)    | 105 ± 4    | — | 101-113  |
| Cholesterol (mg/dL) | 172 ± 28   | — | —        |
| CK (U/L)            | —          | — | 110-480  |
| Creatinine (mg/dL)  | 0.8 ± 0.3  | — | 0.3-0.4  |
| GGT (U/L)           | 2 ± 3      | — | 0-2.9    |

| Measurement           | Canada Goose ( <i>Branta canadensis</i> ) <sup>187,188</sup> | Mallard Duck ( <i>Anas platyrhynchos</i> ) <sup>187</sup> | Wood Duck ( <i>Aix sponsa</i> ) <sup>187</sup> |
|-----------------------|--------------------------------------------------------------|-----------------------------------------------------------|------------------------------------------------|
| Glucose (mg/dL)       | 210 ± 31                                                     | —                                                         | 232-269                                        |
| LDH (U/L)             | 301 ± 80                                                     | —                                                         | 30-205                                         |
| Phosphorus (mg/dL)    | 2.8 ± 0.9                                                    | —                                                         | 1.8-4.1                                        |
| Potassium (mEq/L)     | 3.4 ± 0.6                                                    | —                                                         | 3.9-4.7                                        |
| Protein, total (g/dL) | 4.8 ± 0.7                                                    | —                                                         | 2.1-3.3                                        |
| Albumin (g/dL)        | 2.1 ± 0.2                                                    | —                                                         | 1.5-2.1                                        |
| Globulin (g/dL)       | 2.8 ± 0.6                                                    | —                                                         | 0.6-1.2                                        |
| A:G ratio             | 0.76 ± 0.13                                                  | —                                                         | 1.5-3.6                                        |
| Sodium (mEq/L)        | 142 ± 4                                                      | —                                                         | 141-149                                        |
| Uric acid (mg/dL)     | 8.3 ± 2.3                                                    | —                                                         | 2.5-12.9                                       |

TABLE 5-24 Hematologic and Serum Biochemical Values of Selected Ratites.

| Measurement               | Emu ( <i>Dromaius novaehollandiae</i> ) <sup>184,185</sup> | Ostrich ( <i>Struthio camelus</i> ) <sup>184</sup> | Rhea ( <i>Rhea spp</i> ) <sup>181</sup> |
|---------------------------|------------------------------------------------------------|----------------------------------------------------|-----------------------------------------|
| <b>Hematology</b>         |                                                            |                                                    |                                         |
| PCV (%)                   | 40-60                                                      | 32 ± 3                                             | 29-59                                   |
| RBC (10 <sup>6</sup> /μL) | 2.5-4.5                                                    | 1.7 ± 0.4                                          | —                                       |
| Hgb (g/dL)                | —                                                          | 12.2 ± 2.0                                         | 64-170 (126)                            |
| MCV (fL)                  | —                                                          | 174 ± 42                                           | —                                       |
| MCH (pg)                  | —                                                          | —                                                  | —                                       |
| MCHC (g/dL)               | —                                                          | 33 ± 5                                             | 44.4-45.7 (45.1)                        |
| WBC (10 <sup>3</sup> /μL) | 8-25                                                       | 5.5 ± 1.9                                          | 4.1-25.7 (11.8)                         |
| Heterophils (%)           | 45-75                                                      | 63 ± 8                                             | —                                       |
| Lymphocytes (%)           | 20-40                                                      | 34 ± 7                                             | —                                       |
| Monocytes (%)             | 0-2                                                        | 3 ± 1                                              | —                                       |
| Eosinophils (%)           | 0-1                                                        | 0.3 ± 0.5                                          | —                                       |
| Basophils (%)             | 0-1                                                        | 0.2 ± 0.5                                          | —                                       |



| Chemistries         |          |            |            |
|---------------------|----------|------------|------------|
| ALP (U/L)           | —        | 575 ± 248  | —          |
| AST (U/L)           | 80-380   | 131 ± 31   | 20-192     |
| Bile acid (μmol/L)  |          |            |            |
| RIA                 | 6-45     | —          | —          |
| Colorimetric        | —        | —          | —          |
| Calcium (mg/dL)     | 8.8-12.5 | 9.2        | 2.6-8.2    |
| Chloride (mEq/L)    | —        | 100 ± 16   | —          |
| Cholesterol (mg/dL) | 68-170   | 108        | —          |
| CK (U/L)            | 100-750  | 688 ± 208  | 0-2640     |
| Creatinine (mg/dL)  | 0.22     | 0.32       | —          |
| GGT (U/L)           | —        | 1.5 ± 2.9  | —          |
| Glucose (mg/dL)     | 100-290  | 250        | 37.8-158.6 |
| LDH (U/L)           | 310-1200 | 1565 ± 660 | 269-1640   |
| Phosphorus (mg/dL)  | 3.8-7.2  | 3.7        | —          |

| Measurement           | Emu ( <i>Dromaius novaehollandiae</i> ) <sup>184,493</sup> | Ostrich ( <i>Struthio camelus</i> ) <sup>494</sup> | Rhea ( <i>Rhea</i> spp) <sup>491</sup> |
|-----------------------|------------------------------------------------------------|----------------------------------------------------|----------------------------------------|
| Potassium (mEq/L)     | 3.5-6.5                                                    | 3 ± 0.8                                            | —                                      |
| Protein, total (g/dL) | 3.4-5.6                                                    | 3.7 ± 0.7                                          | 3.4-6.2                                |
| Albumin (g/dL)        | 1-2.5                                                      | —                                                  | —                                      |
| Sodium (mEq/L)        | —                                                          | 147 ± 34                                           | —                                      |
| Uric acid (mg/dL)     | 4.5-14                                                     | 8.2                                                | —                                      |

<sup>494</sup>Levi A, Perelman B, Wener T, et al. Haematological parameters of the ostrich (*Struthio camelus*). *Avian Pathol* 1989;18: 321-327.

TABLE 5-25 Hematologic and Serum Biochemical Values of Selected Piciformes and Columbiformes.

| Measurement               | Toco Toucan ( <i>Ramphastos toco</i> ) <sup>a,160,273</sup> | Pigeon ( <i>Columba livia</i> ) <sup>387,480,693</sup> |
|---------------------------|-------------------------------------------------------------|--------------------------------------------------------|
| <b>Hematology</b>         |                                                             |                                                        |
| PCV (%)                   | 45-60 (46)                                                  | 39.3-59.4                                              |
| RBC (10 <sup>6</sup> /μL) | 2.5-4.5 (2.5)                                               | 2.1-4.2                                                |
| Hgb (g/dL)                | 14.6-18.2 (16.4)                                            | 10.7-14.9                                              |
| MCV (fL)                  | 176-214 (196)                                               | 118-144                                                |
| MCH (pg)                  | 53-76 (65)                                                  | 32-48                                                  |
| MCHC (g/dL)               | 31-39 (35)                                                  | 20-30                                                  |
| WBC (10 <sup>3</sup> /μL) | 4-10 (5.5)                                                  | 10-30                                                  |
|                           |                                                             |                                                        |



|                       |         |          |
|-----------------------|---------|----------|
| Heterophils (%)       | 35-65   | 15-50    |
| Lymphocytes (%)       | 25-50   | 25-70    |
| Monocytes (%)         | —       | 1-3      |
| Eosinophils (%)       | 0-4     | 0-1.5    |
| Basophils (%)         | 0-5     | 0-1      |
| H:L ratio             | —       | 0.21-2   |
| <b>Chemistries</b>    |         |          |
| ALP (U/L)             | —       | 160-780  |
| ALT (U/L)             | —       | 19-48    |
| AST (U/L)             | 130-330 | 45-123   |
| Bile acid (μmol/L)    |         |          |
| RIA                   | 20-40   | 22-60    |
| Colorimetric          | —       | —        |
| Calcium (mg/dL)       | 10-15   | 7.6-10.4 |
| Chloride (mEq/L)      | —       | 101-113  |
| Cholesterol (mg/dL)   | —       | —        |
| CK (U/L)              | —       | 110-480  |
| Creatinine (mg/dL)    | 0.1-0.4 | 0.3-0.4  |
| GGT (U/L)             | —       | 0-2.9    |
| Glucose (mg/dL)       | 220-350 | 232-269  |
| LDH (U/L)             | 200-400 | 30-205   |
| Phosphorus (mg/dL)    | —       | 1.8-4.1  |
| Potassium (mEq/L)     | —       | 3.9-4.7  |
| Protein, total (g/dL) | 3-5     | 2.1-3.3  |
| Albumin (g/dL)        | —       | 1.5-2.1  |
| Globulin (g/dL)       | —       | 0.6-1.2  |
| A:G ratio             | —       | 1.5-3.6  |
| Sodium (mEq/L)        | —       | 141-149  |
| Uric acid (mg/dL)     | 4-14    | 2.5-12.9 |

<sup>a</sup> Numbers in parentheses represent the mean.

TABLE 5-26 Hematologic and Serum Biochemical Values of Selected Raptors.<sup>a</sup>

## Measurement

Bald Eagle (*Haliaeetus  
leucocephalus*)<sup>15,107,704</sup>Golden Eagle (*Aquila  
chrysaetos*)<sup>33,363</sup>

## Hematology

|                           |                       |                  |
|---------------------------|-----------------------|------------------|
| PCV (%)                   | 44 ± 4                | 35-47 (41)       |
| RBC (10 <sup>6</sup> /μL) | —                     | 1.9-2.7 (2.4)    |
| Hgb (g/dL)                | —                     | 12.1-15.2 (13.8) |
| MCV (fL)                  | —                     | 160-184 (174)    |
| MCH (pg)                  | —                     | 56.3-62.7 (58.9) |
| MCHC (g/dL)               | —                     | 32.3-35.9 (34)   |
| WBC (10 <sup>3</sup> /μL) | 4.6-32.5 (12.8 ± 4.8) | 5.9-24 (12.3)    |
| Heterophils (%)           | 19-61 (44)            | 49-86            |
| Lymphocytes (%)           | 23-60 (38)            | 14-38            |
| Monocytes (%)             | 0-8 (4)               | 0-9              |
| Eosinophils (%)           | 4-26 (13)             | 1-5              |
| Basophils (%)             | —                     | 0-1              |
| H:L ratio                 | —                     | —                |
| Fibrinogen (g/L)          | —                     | 2-4.1 (2.9)      |

## Chemistries

|                     |          |         |
|---------------------|----------|---------|
| ALP (U/L)           | 23-30    | 15-36   |
| ALT (U/L)           | 25       | —       |
| AST (U/L)           | 153-370  | 95-210  |
| Bile acid (μmol/L)  |          |         |
| RIA                 | —        | —       |
| Calcium (mg/dL)     | 8.2-10.6 | 7.4-9.5 |
| Chloride (mEq/L)    | —        | —       |
| Cholesterol (mg/dL) | —        | —       |
| CK (U/L)            | —        | —       |
| GGT (U/L)           | —        | —       |
| Glucose (mg/dL)     | 285-400  | 250-408 |
| LDH (U/L)           | —        | 320-690 |

| Measurement           | Bald Eagle ( <i>Haliaeetus leucocephalus</i> ) <sup>107,107,104</sup> | Golden Eagle ( <i>Aquila chrysaetos</i> ) <sup>133,140</sup> |
|-----------------------|-----------------------------------------------------------------------|--------------------------------------------------------------|
| Phosphorus (mg/dL)    | 2.4-4.3                                                               | 1.9-3.6                                                      |
| Potassium (mEq/L)     | —                                                                     | —                                                            |
| Protein, total (g/dL) | 3-4.1 (4 ± 1)                                                         | 2.5-3.9                                                      |
| Albumin (g/dL)        | —                                                                     | 1-1.4                                                        |
| Globulin (g/dL)       | —                                                                     | —                                                            |
| A:G ratio             | —                                                                     | —                                                            |
| Sodium (mEq/L)        | —                                                                     | —                                                            |
| Uric acid (mg/dL)     | 5.5-14.8                                                              | 4.4-12                                                       |

\*Numbers in parentheses represent the mean.

| Measurement | Red-Shouldered Hawk ( <i>Buteo lineatus</i> ) <sup>104</sup> | Red-Tailed Hawk ( <i>Buteo jamaicensis</i> ) <sup>104</sup> | Harris Hawk ( <i>Parabuteo unicinctus</i> ) <sup>107,107,104</sup> |
|-------------|--------------------------------------------------------------|-------------------------------------------------------------|--------------------------------------------------------------------|
|-------------|--------------------------------------------------------------|-------------------------------------------------------------|--------------------------------------------------------------------|

### Hematology

|                           |      |           |         |
|---------------------------|------|-----------|---------|
| PCV (%)                   | 40.9 | 31-43     | —       |
| RBC (10 <sup>6</sup> /μL) | 2.4  | 2.4-3.6   | —       |
| Hgb (g/dL)                | 15   | 10.7-16.6 | —       |
| MCV (fL)                  | 171  | 150-178   | —       |
| MCH (pg)                  | 62.6 | 46-57.4   | —       |
| MCHC (g/dL)               | 36.7 | 297-345   | —       |
| WBC (10 <sup>3</sup> /μL) | —    | 19.1-33.4 | 4.8-10  |
| Heterophils (%)           | —    | 35 ± 11   | 2.3-6.7 |
| Lymphocytes (%)           | —    | 44 ± 9    | 0.6-2.4 |
| Monocytes (%)             | —    | 6 ± 3     | 0.2-1.5 |
| Eosinophils (%)           | —    | 13 ± 4    | 0-0.8   |
| Basophils (%)             | —    | Rare      | 0-1.6   |
| H:L ratio                 | —    | —         | —       |
| Fibrinogen (g/L)          | —    | —         | —       |

## Chemistries

|                     |   |          |          |
|---------------------|---|----------|----------|
| ALP (U/L)           | — | 22-138   | 15-36    |
| ALT (U/L)           | — | 3-50     | —        |
| AST (U/L)           | — | 76-492   | 95-210   |
| Bile acid (μmol/L)  |   |          |          |
| RIA                 | — | 8.4-10.2 | —        |
| Calcium (mg/dL)     | — | 10-12.8  | 8.4-10.6 |
| Chloride (mEq/L)    | — | 118-129  | 113-119  |
| Cholesterol (mg/dL) | — | —        | —        |
| CK (U/L)            | — | —        | 224-650  |
| GGT (U/L)           | — | 0-20     | 2-6.9    |
| Glucose (mg/dL)     | — | 292-390  | 220-283  |
| LDH (U/L)           | — | 0-2640   | 160-563  |

| Measurement           | Red-Shouldered Hawk ( <i>Buteo lineatus</i> ) <sup>704</sup> | Red-Tailed Hawk ( <i>Buteo jamaicensis</i> ) <sup>704</sup> | Harris Hawk ( <i>Parabuteo unicinctus</i> ) <sup>107,382,704</sup> |
|-----------------------|--------------------------------------------------------------|-------------------------------------------------------------|--------------------------------------------------------------------|
| Phosphorus (mg/dL)    | —                                                            | 1.9-4                                                       | 3-4.4                                                              |
| Potassium (mEq/L)     | —                                                            | 2.6-4.3                                                     | 0.8-2.3                                                            |
| Protein, total (g/dL) | —                                                            | 3.9-6.7                                                     | 3.1-4.6                                                            |
| Albumin (g/dL)        | —                                                            | —                                                           | 1.4-1.7                                                            |
| Globulin (g/dL)       | —                                                            | —                                                           | 2.1-2.9                                                            |
| A:G ratio             | —                                                            | —                                                           | 0.45-0.55                                                          |
| Sodium (mEq/L)        | —                                                            | 143-162                                                     | 155-171                                                            |
| Uric acid (mg/dL)     | —                                                            | 8.1-16.8                                                    | 9-13.2                                                             |

<sup>a</sup>WBC count and differentials for Harris hawk are absolute values.

*Continued*

| Measurement | Sharp-Shinned Hawk<br>( <i>Accipiter striatus</i> ) <sup>127</sup> | Turkey Vulture<br>( <i>Cathartes aura</i> ) <sup>104</sup> |
|-------------|--------------------------------------------------------------------|------------------------------------------------------------|
|-------------|--------------------------------------------------------------------|------------------------------------------------------------|

### Hematology

|                           |          |                  |
|---------------------------|----------|------------------|
| PCV (%)                   | 44-52    | 51-58 (54)       |
| RBC (10 <sup>6</sup> /μL) | —        | 2.4-2.9 (2.7)    |
| Hgb (g/dL)                | —        | 15.7-17.3 (16.3) |
| MCV (fL)                  | —        | 194-224 (204)    |
| MCH (pg)                  | —        | 58.6-65 (61.7)   |
| MCHC (g/dL)               | —        | 28.6-32 (30.2)   |
| WBC (10 <sup>3</sup> /μL) | 7.7-16.8 | 10.5-31.9 (20.1) |
| Heterophils (%)           | 16-24    | 59-64            |
| Lymphocytes (%)           | 54-75    | 8-18             |
| Monocytes (%)             | 0-3      | 0-1              |
| Eosinophils (%)           | 5-11     | 3-4              |
| Basophils (%)             | 0-1      | 0                |

### Chemistries

|                       |         |   |
|-----------------------|---------|---|
| ALP (U/L)             | —       | — |
| ALT (U/L)             | —       | — |
| AST (U/L)             | —       | — |
| Bile acid (μmol/L)    |         |   |
| RIA                   | —       | — |
| Calcium (mg/dL)       | —       | — |
| Chloride (mEq/L)      | —       | — |
| Cholesterol (mg/dL)   | —       | — |
| CK (U/L)              | —       | — |
| GGT (U/L)             | —       | — |
| Glucose (mg/dL)       | —       | — |
| LDH (U/L)             | —       | — |
| Phosphorus (mg/dL)    | —       | — |
| Potassium (mEq/L)     | —       | — |
| Protein, total (g/dL) | 2.4-3.2 | — |

| Measurement       | Sharp-Shinned Hawk<br>( <i>Accipiter striatus</i> ) <sup>1027</sup> | Turkey Vulture<br>( <i>Cathartes aura</i> ) <sup>704</sup> |
|-------------------|---------------------------------------------------------------------|------------------------------------------------------------|
| Albumin (g/dL)    | —                                                                   | —                                                          |
| Globulin (g/dL)   | —                                                                   | —                                                          |
| A:G ratio         | —                                                                   | —                                                          |
| Sodium (mEq/L)    | —                                                                   | —                                                          |
| Uric acid (mg/dL) | —                                                                   | —                                                          |

| Measurement | Eurasian Eagle Owl<br>( <i>Bubo bubo</i> ) <sup>133, 702</sup> | Great-Horned Owl<br>( <i>Bubo virginianus</i> ) <sup>106, 107, 704</sup> | Barn Owl ( <i>Tyto alba</i> ) <sup>107, 233, 704</sup> |
|-------------|----------------------------------------------------------------|--------------------------------------------------------------------------|--------------------------------------------------------|
|-------------|----------------------------------------------------------------|--------------------------------------------------------------------------|--------------------------------------------------------|

Hematology

|                           |                        |         |                           |
|---------------------------|------------------------|---------|---------------------------|
| PCV (%)                   | 39                     | 43 ± 3  | 46 ± 3                    |
| RBC (10 <sup>6</sup> /μL) | 1.4-2.3 (1.9 ± 0.2)    | 1.7     | 2.2-3 (2.7 ± 0.3)         |
| Hgb (g/dL)                | 11.7-16.8 (14.2 ± 1.5) | 12.2    | 12.7-16.4<br>(14.2 ± 1.5) |
| MCV (fL)                  | 178-239 (207 ± 17)     | 188     | 176 ± 22                  |
| MCH (pg)                  | 67.1-87.1 (75.1 ± 8.1) | 72      | 51.1 ± 5.7                |
| MCHC (g/dL)               | 33.8-38.4 (36.3 ± 2)   | 38      | 31.8 ± 2.2                |
| WBC (10 <sup>3</sup> /μL) | 5-22 (11 ± 4)          | 6-8     | 16.6 ± 4.2                |
| Heterophils (%)           | 64                     | 47 ± 11 | 15-50                     |
| Lymphocytes (%)           | 35                     | 27 ± 7  | 40-70                     |
| Monocytes (%)             | 0                      | 9 ± 3.6 | 0-3                       |
| Eosinophils (%)           | 0-1.6                  | 1 ± 1.2 | 5-25                      |
| Basophils (%)             | 0-0.6                  | Rare    | 0-2                       |
| H:L ratio                 | —                      | —       | —                         |
| Fibrinogen (g/L)          | 1.4-5 (3.3 ± 0.9)      | —       | 1.9-3.3 (2.7 ± 0.5)       |

Chemistries

|                 |          |      |        |
|-----------------|----------|------|--------|
| ALP (U/L)       | —        | 31   | 21-108 |
| ALT (U/L)       | —        | 39   | 0-59   |
| AST (U/L)       | —        | 287  | 32-538 |
| Calcium (mg/dL) | 8.8-10.4 | 10.2 | —      |

Continued

| Measurement           | Eurasian Eagle Owl<br>( <i>Bubo bubo</i> ) <sup>133,382</sup> | Great-Horned Owl ( <i>Bubo virginianus</i> ) <sup>108,167,704</sup> | Barn Owl ( <i>Tyto alba</i> ) <sup>109,333,704</sup> |
|-----------------------|---------------------------------------------------------------|---------------------------------------------------------------------|------------------------------------------------------|
| Cholesterol (mg/dL)   | 151-274                                                       | —                                                                   | —                                                    |
| GGT (U/L)             | —                                                             | —                                                                   | 0-15                                                 |
| Glucose (mg/dL)       | 243-391                                                       | 356                                                                 | —                                                    |
| LDH (U/L)             | —                                                             | —                                                                   | 109-1320                                             |
| Phosphorus (mg/dL)    | —                                                             | 4.3                                                                 | —                                                    |
| Protein, total (g/dL) | 3-3.5                                                         | 4.3                                                                 | 3.9-6.3                                              |
| Albumin (g/dL)        | 1.1-1.4                                                       | 1.3                                                                 | —                                                    |
| Globulin (g/dL)       | 1.9-2.2                                                       | —                                                                   | —                                                    |
| Uric acid (mg/dL)     | 8-14                                                          | 13.7                                                                | —                                                    |

| Measurement | American Kestrel<br>( <i>Falco sparverius</i> ) <sup>8</sup> | Gyr Falcon<br>( <i>Falco rusticolus</i> ) <sup>704</sup> | Peregrine Falcon<br>( <i>Falco peregrinus</i> ) <sup>382,835,704</sup> |
|-------------|--------------------------------------------------------------|----------------------------------------------------------|------------------------------------------------------------------------|
|-------------|--------------------------------------------------------------|----------------------------------------------------------|------------------------------------------------------------------------|

Hematology

|                           |           |           |                 |
|---------------------------|-----------|-----------|-----------------|
| PCV (%)                   | 43 ± 3.2  | 49 ± 2    | 37-53           |
| RBC (10 <sup>6</sup> /μL) | —         | —         | 3-4             |
| Hgb (g/dL)                | —         | —         | 118-188         |
| MCV (fL)                  | 14.5-57   | —         | 118-176         |
| MCH (pg)                  | 11-33     | —         | 40-48.4         |
| MCHC (g/dL)               | 24-58     | —         | 319-352         |
| WBC (10 <sup>3</sup> /μL) | 9.8 ± 4.9 | 4.6 ± 1.7 | 3.3-21 (13 ± 3) |
| Heterophils (%)           | 47 ± 3    | 51 ± 5    | 65 ± 12         |
| Lymphocytes (%)           | 46 ± 3    | 45 ± 5    | 35 ± 13         |
| Monocytes (%)             | 2 ± 0.2   | 1 ± 1     | 0               |
| Eosinophils (%)           | 1 ± 0.2   | 1 ± 1     | 0               |
| Basophils (%)             | 2 ± 0.2   | Rare      | 0               |



| Measurement           | American Kestrel<br>( <i>Falco sparverius</i> ) <sup>c</sup> | Gyr Falcon<br>( <i>Falco rusticolus</i> ) <sup>704</sup> | Peregrine Falcon<br>( <i>Falco peregrinus</i> )<br>382,635,704 |
|-----------------------|--------------------------------------------------------------|----------------------------------------------------------|----------------------------------------------------------------|
| <b>Chemistries</b>    |                                                              |                                                          |                                                                |
| ALP (U/L)             | 232 ± 72                                                     | 257                                                      | 97-350                                                         |
| ALT (U/L)             | 41 ± 33                                                      | —                                                        | 19-54                                                          |
| AST (U/L)             | 77 ± 29                                                      | 97                                                       | 20-52                                                          |
| Bile acid (μmol/L)    |                                                              |                                                          |                                                                |
| RIA                   | —                                                            | —                                                        | 20-118                                                         |
| Calcium (mg/dL)       | 7.1 ± 0.8                                                    | 9.6                                                      | 8.4-10.2                                                       |
| Chloride (mEq/L)      | 108 ± 33                                                     | 125                                                      | 121-134                                                        |
| Cholesterol (mg/dL)   | —                                                            | —                                                        | 175-401                                                        |
| CK (U/L)              | 1739 ± 734                                                   | 402                                                      | 357-850                                                        |
| GGT (U/L)             | —                                                            | —                                                        | 0-7                                                            |
| Glucose (mg/dL)       | 305 ± 40                                                     | 318                                                      | 11-16                                                          |
| LDH (U/L)             | —                                                            | —                                                        | 625-1210                                                       |
| Phosphorus (mg/dL)    | 3 ± 0.9                                                      | —                                                        | 3.4                                                            |
| Potassium (mEq/L)     | 2.2 ± 0.7                                                    | —                                                        | 1.6-3.2                                                        |
| Protein, total (g/dL) | 3.2 ± 0.5                                                    | 2.89                                                     | 2.5-4                                                          |
| Albumin (g/dL)        | 1 ± 0.2                                                      | —                                                        | 0.8-1.3                                                        |
| Globulin (g/dL)       | 1.2 ± 0.4                                                    | —                                                        | 1.6-2.8                                                        |
| A:G ratio             | 0.9 ± 0.4                                                    | —                                                        | 0.4-0.6                                                        |
| Sodium (mEq/L)        | 158 ± 3                                                      | 160                                                      | 152-168                                                        |
| Uric acid (mg/dL)     | 9 ± 6                                                        | 13.9                                                     | 4.4-22                                                         |

<sup>c</sup>Dressen PJ, Wimsatt J, Burkhard MJ. The effects of isoflurane anesthesia on hematologic and plasma biochemical values of American kestrels (*Falco sparverius*). *J Avian Med Surg* 1999;13:173-179.

TABLE 5-27 Biologic and Physiologic Values of Selected Avian Species.<sup>a,15,36,138,139,189,191,212,265,329,330,387,423,553,679,735,775,837</sup>



| Species                       | Incubation<br>Period (days) | Fledgling<br>Age (days) | Weaning Age (days) |             | Sexual Maturity | Lifespan in Captivity<br>(Maximum) (years) | Body Weight (g)     |
|-------------------------------|-----------------------------|-------------------------|--------------------|-------------|-----------------|--------------------------------------------|---------------------|
|                               |                             |                         | Parent-Raised      | Hand-Reared |                 |                                            |                     |
| Psittaciformes                |                             |                         |                    |             |                 |                                            |                     |
| African grey parrot           | 26-28 <sup>a</sup>          | 50-65                   | 100-120            | 75-90       | 4-6 yr          | 50-60                                      | 454 (370-534)       |
| Amazon parrot                 | 24-29 <sup>a</sup>          | 45-60                   | 90-120             | 75-90       | 4-6 yr          | >50 (80)                                   | f                   |
| Australian parakeet           | 18-19                       | 30-45                   | 50-65              | —           | 1-3 yr          | 10-12                                      | 30-110              |
| Budgerigar parakeet           | 16-18                       | 22-26                   | 30-40              | 30          | 6-9 mo          | 5-10 (18)                                  | 30                  |
| Cockatiel                     | 18-20                       | 32-38                   | 47-52              | 42-49       | 6-12 mo         | 10-12 (30)                                 | 80-90               |
| Cockatoo, galah               | 22-24                       | 45-55                   | 90-120             | 80-90       | 1 yr            | 40-60                                      | g                   |
| Cockatoo, large               | h                           | 60-80                   | 120-150            | 95-120      | 5-6 yr          | 50-60                                      | g                   |
| Cockatoo, medium              | h                           | 45-60                   | 90-120             | 75-100      | 3-4 yr          | 40-60                                      | g                   |
| Conure                        | i                           | 35-40                   | 45-70              | 60          | 2-3 yr          | 25-40                                      | 80-100 <sup>j</sup> |
| Eclectus parrot               | 26-28                       | 72-80                   | 120-150            | 100-110     | 4 yr            | 20-40 (80)                                 | 432 (347-512)       |
| Lorylorikeet                  | 21-27                       | 42-50                   | 62-70              | 50-60       | 2 yr            | 20-30                                      | —                   |
| Lovebirds                     | 18-24                       | 30-35                   | 45-55              | 40-45       | 6-12 mo         | 15-30                                      | 42-48               |
| Macaw, large                  | 26-28                       | 70-80                   | 120-150            | 95-120      | 5-7 yr          | 75-100                                     | k                   |
| Macaw, small                  | 23-26                       | 45-60                   | 90-120             | 75-90       | 4-6 yr          | 50-80                                      | k                   |
| Ring-neck parakeet,<br>Indian | 22-23                       | 40-45                   | 55-65              | —           | 3 yr            | 18-25                                      | 115                 |
| Passeriformes                 |                             |                         |                    |             |                 |                                            |                     |
| Canary                        | 12-14                       | 14                      | 21                 | —           | < 1 yr          | 6-12                                       | 12-30               |
| Mynah                         | 14-15                       | 30                      | 60                 | —           | 2-3 yr          | 12                                         | 180-260             |
| Zebra or society finch        | 12-16                       | 18-20                   | 25-28              | —           | 9-10 mo         | 4-7                                        | 10-16               |
| Columbiformes                 |                             |                         |                    |             |                 |                                            |                     |
| Dove, common ground           | 12->14                      | 18                      | —                  | —           | 1 yr            | 4-8                                        | 30                  |
| Dove, mourning                | 13-14                       | 12-14                   | —                  | —           | —               | —                                          | 120                 |
| Pigeon (rock dove)            | 16-19                       | 28-35                   | 35                 | —           | 1 yr            | 4-8 (>20)                                  | 240-300             |
| Galliformes                   |                             |                         |                    |             |                 |                                            |                     |
| Bobwhite quail                | —                           | —                       | Precocial          | —           | —               | 6                                          | —                   |
| Peafowl                       | —                           | 12                      | Precocial          | —           | —               | 20                                         | —                   |
| Pheasant, ring-necked         | 22-24                       | —                       | Precocial          | —           | 1 yr            | 10-18                                      | 1150                |

Continued

| Species | Incubation Period (days) | Fledgling Age (days) | Weaning Age (days) |             | Sexual Maturity | Lifespan in Captivity (Maximum) (years) | Body Weight (g) |
|---------|--------------------------|----------------------|--------------------|-------------|-----------------|-----------------------------------------|-----------------|
|         |                          |                      | Parent-Raised      | Hand-Reared |                 |                                         |                 |
| Ratites |                          |                      |                    |             |                 |                                         |                 |
| Emu     | 50-57                    | —                    | Precocial          | —           | 3-5 yr          | 30                                      | 40-45 kg        |
| Ostrich | 41-43                    | —                    | Precocial          | —           | 4 yr            | 80                                      | 120-160 kg      |
| Rhea    | 36-41                    | —                    | Precocial          | —           | 1.5-2 yr        | —                                       | 25 kg           |

\*Guidelines only; data vary between references. For waterfowl and captons, see Tables 5-28 and 5-29.  
 †Ecotopics parakeets, 22; Pionus parrot, 25-26; Psittacula parakeets, 23-26; Quaker parakeet, 23; Senegal parrot, 24-25.  
 ‡Bourke's parakeet, 40 (35-50); kakariki parakeet, 95-100; Princess of Wales parakeet, 108 (100-129); red-rumped parakeet, 65 (50-88).  
 §Congo, 26; Timneh, 26.  
 ¶Green-cheeked, blue-fronted, 26; spectacled (white-fronted), 24; yellow-naped, yellow-fronted, yellow-crowned, double yellow-headed, 28-29.  
 ††Blue-crowned, 740 (618-958); blue-fronted, 432 (361-485); double yellow-headed, 568 (463-694); Mexican red-headed, 360 (343-377); yellow-naped, 596 (476-706).  
 †††Bare-eyed, 331; greater sulphur-crested, 806; Leadbeater's (Major Mitchell's), 423 (361-474); lesser sulphur-crested, 300; Moluccan, 808; rose-breasted, 298; titian, 559; umbrella, 552.  
 ††††Bare-eyed, 23-24; citron-crested, 25-26; greater sulphur-crested, 27-28; Leadbeater's (Major Mitchell's), 26; lesser sulphur-crested, 24-25; Moluccan, 28-29; palm, 28-30; titian, 27-28; umbrella, 28.  
 †††††Blue-crowned, 23-24; orange-fronted, 30; Nanday, 21-23; Patagonian, 24-25; sun, 27-28.  
 ††††††Queen of Bavaria, 262 (252-276).  
 †††††††Blue and gold, 1021; green-winged, 1179; hyacinth, 1355 (1197-1495); military, 788; red-fronted, 458; scarlet, 1103.

TABLE 5-28 Biologic and Physiologic Values of Selected Anseriformes (Waterfowl) Species.[212,263,735](#)

| Species            | Clutch Size | Incubation Period (days) | Fledgling (days) | Sexual Maturity (yr) | Longevity (yr) | Weight (kg) |           | Respiratory Rate (breaths per minute) | Heart Rate (beats per minute) |
|--------------------|-------------|--------------------------|------------------|----------------------|----------------|-------------|-----------|---------------------------------------|-------------------------------|
|                    |             |                          |                  |                      |                | Male        | Female    |                                       |                               |
| Bor-headed goose   | 4-6         | 27                       | —                | 2                    | 15-20          | 2-3         | 2-3       | 13-40                                 | 80-150                        |
| Canada goose       | 4-10        | 25-30                    | 40-73            | —                    | —              | —           | —         | —                                     | —                             |
| Common eider       | 3-6         | 25-30                    | 65-75            | 1                    | 10-15          | 2.25        | 2.12      | 30-95                                 | 180-230                       |
| European goldeneye | 9-11        | 27-32                    | —                | 1                    | 10-15          | 0.99-1.16   | 0.7-0.8   | 30-95                                 | 180-230                       |
| European wigeon    | 7-11        | 23-25                    | —                | 1                    | 10-15          | 0.7         | 0.64      | 30-95                                 | 180-230                       |
| Hawaiian goose     | 3-5         | 29                       | —                | 2                    | 15-20          | 2.2         | 1.9       | 13-40                                 | 80-150                        |
| Mallard†           | 8-12        | 23-29                    | 42-60            | 1                    | 10-15          | 1.26        | 1.1       | 30-95                                 | 180-230                       |
| Mandarin duck      | 9-12        | 28-30                    | —                | 1                    | 10-15          | 0.44-0.55   | 0.44-0.55 | 30-95                                 | 180-230                       |
| Muscovy duck       | 8-15        | 35                       | —                | 1                    | 10-15          | 2-4         | 1.1-1.5   | 30-95                                 | 180-230                       |
| Mute swan          | 4-8         | 35-40                    | —                | 5                    | 25-30          | 12.2        | 8.9       | 13-40                                 | 80-150                        |
| Pink-footed goose  | 3-5         | 26-27                    | —                | 2                    | 15-20          | 2.6         | 2.35      | 13-40                                 | 80-150                        |
| Red-breasted goose | 3-7         | 23-25                    | —                | 2                    | 15-20          | 1.3-1.6     | 1.15      | 13-40                                 | 80-150                        |
| Tufted duck        | 6-14        | 23-25                    | —                | 1                    | 10-15          | 1.1         | 1.05      | 30-95                                 | 180-230                       |

†Except for the Muscovy, all breeds of domestic duck are descended from the mallard (*Anas platyrhynchos*).

TABLE 5-29 Biologic and Physiologic Values of Selected Raptors.[62,125,212,263,318,704,735](#)

| Species               | Clutch Size | Incubation Period (days) | Interval Between Eggs (days) | Start of Incubation        | Fledging (days) | Sexual Maturity (yr) | Longevity (yr) | Body Weight  |              |
|-----------------------|-------------|--------------------------|------------------------------|----------------------------|-----------------|----------------------|----------------|--------------|--------------|
|                       |             |                          |                              |                            |                 |                      |                | Male         | Female       |
| American kestrel      | 3-7         | 29-31                    | —                            | —                          | 30-31           | —                    | 2-7            | 103-120 g    | 126-166 g    |
| Bald eagle            | 1-3         | 34-36                    | —                            | —                          | 70-98           | —                    | —              | 4.1 kg       | 5.8 kg       |
| Barn owl              | 2-9         | 30-31                    | 2-3                          | First egg                  | 70-75           | 1                    | —              | 441-470 g    | 490-570 g    |
| Barred owl            | 2-4         | 28-33                    | —                            | —                          | 42              | —                    | —              | 630 g        | 800 g        |
| Black vulture         | 1-3         | 37-48                    | —                            | —                          | 80-94           | —                    | —              | a            | a            |
| Common kestrel        | 3-6         | 27-29                    | 1-2                          | Second to third egg        | —               | 1                    | —              | 136-252 g    | 154-314 g    |
| Cooper's hawk         | 3-6         | 32-36                    | —                            | —                          | 27-34           | —                    | —              | 220-410 g    | 330-680 g    |
| Eurasian buzzard      | 2-4         | 36-38                    | 3                            | First to sec-<br>ond egg   | —               | 2-3                  | —              | 0.55-0.85 kg | 0.7-1.2 kg   |
| Eurasian eagle owl    | 2-4         | 34-36                    | 2-3                          | First to sec-<br>ond egg   | 90              | 2-3                  | 50-60          | 1.5-2.8 kg   | 1.8-4.2 kg   |
| Golden eagle          | 1-3         | 43-45                    | —                            | —                          | 70              | >5                   | 50-60          | 2.5-4 kg     | 3.25-6.35 kg |
| Gyr falcon            | 3-5         | 34-36                    | —                            | —                          | 49-56           | —                    | —              | 0.96-1.3 kg  | 1.3-2.1 kg   |
| Harris hawk           | 2-5         | 32                       | 2-3                          | Penultimate<br>or last egg | 43-49           | >3                   | 20-30          | 0.7 kg       | 1 kg         |
| Merlin                | 2-7         | 28-32                    | —                            | —                          | 30-35           | 2                    | 10-14          | 150-210 g    | 189-255 g    |
| Northern goshawk      | 3-5         | 35-38                    | 2-3                          | First to sec-<br>ond egg   | 35-42           | >3                   | 15-20          | 0.5-1.2 kg   | 0.8-1.5 kg   |
| Northern sparrow hawk | 4-6         | 35                       | 2-3                          | Third to fourth egg        | —               | 1-2                  | —              | —            | —            |
| Osprey                | 2-4         | 32-43                    | —                            | —                          | 48-59           | —                    | —              | b            | b            |
| Peregrine falcon      | 3-4         | 29-32                    | 2-3                          | Penultimate<br>or last egg | 35-42           | >3                   | 15-20          | 440-750 g    | 910-1500 g   |
| Prairie falcon        | 2-7         | 29-33                    | —                            | —                          | 35-42           | —                    | —              | 500-650 g    | 700-975 g    |
| Screech owl, eastern  | 3-4         | —                        | —                            | —                          | —               | —                    | —              | 158-184 g    | 180-220 g    |
| Screech owl, western  | 2-6         | 21-30                    | —                            | —                          | 28              | —                    | —              | 131-210 g    | 157-250 g    |
| Sharp-shinned hawk    | 3-8         | 32-35                    | —                            | —                          | 24-27           | —                    | —              | 82-125 g     | 144-208 g    |
| Snowy owl             | 3-9         | 30-33                    | 2-3                          | First egg                  | 16              | 2                    | —              | 1.6 kg       | 1.1-2 kg     |
| Turkey vulture        | 1-3         | 38-41                    | —                            | —                          | 66-88           | —                    | —              | c            | c            |

\*1.7-2.3 kg; weights of males and females were not listed separately.  
\*1-2.1 kg; weights of males and females were not listed separately, but females are generally 25% heavier than males.  
\*0.8-2.3 kg; weights of males and females were not listed separately, but females are slightly heavier than males.

TABLE 5-30 Quick Reference to Abnormalities of the Standard Avian

Hematology Profile.[274,625](#)

| Parameter   | Increases                                                                                                                                                                                                                                                                                                                                          | Decreases                                                                                                                                                                                                                                                                                                                                                                                                                    |
|-------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| PCV/RBC     | <p>Dehydration</p> <p>Increased oxygen demand</p> <ul style="list-style-type: none"><li>• Chronic obstructive pulmonary disease</li><li>• Obstructive airway disease</li><li>• Chronic respiratory disease</li></ul>                                                                                                                               | <p>Blood loss</p> <ul style="list-style-type: none"><li>• Parasitism</li><li>• Coagulopathies</li><li>• Gastrointestinal bleeding</li><li>• Destruction</li><li>• Hematozoan parasites</li><li>• Bacterial septicemia</li><li>• Aflatoxicosis</li><li>• Chronic inflammatory disease</li><li>• Mycobacteriosis, chlamydophilosis, aspergillosis, chronic hepatitis</li><li>• Neoplasia</li><li>• Lymphoid leukemia</li></ul> |
| Heterophils | <p>Inflammatory processes</p> <ul style="list-style-type: none"><li>• Bacterial (including <i>Mycobacterium</i>) and fungal infections</li><li>• Excess corticosteroids</li><li>• Endogenous production</li><li>• Exogenous administration</li></ul> <p>Birds with a high heterophil: lymphocyte ratio may mount a greater leukocytic response</p> | <p>Infection</p> <ul style="list-style-type: none"><li>• Bacterial and viral (i.e., PBFD)</li></ul> <p>Poor sample preparation, collection, and storage</p>                                                                                                                                                                                                                                                                  |
| Lymphocytes | <p>Chronic antigenic stimulation</p> <ul style="list-style-type: none"><li>• Chronic infections</li></ul> <p>Lymphocytic leukemia</p> <p>Increased excitability</p>                                                                                                                                                                                | <p>Excess corticosteroids</p> <ul style="list-style-type: none"><li>• Endogenous release</li><li>• Exogenous administration</li></ul> <p>Severe viral infection</p> <p>Endotoxemia</p> <p>Septicemia</p> <p>Immunosuppressive drugs</p>                                                                                                                                                                                      |
|             | Chlamydophilosis                                                                                                                                                                                                                                                                                                                                   |                                                                                                                                                                                                                                                                                                                                                                                                                              |

|             |                                                                                                                                           |                                                                                                                                                                                                                                    |
|-------------|-------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Monocytes   | Bacterial infections (including <i>Mycobacterium</i> )<br>Mycotic granulomatous diseases<br>Tissue necrosis<br>Parasitism                 | Acute infection<br>Inflammation                                                                                                                                                                                                    |
| Eosinophils | Gastrointestinal parasitism<br>Delayed Type IV hypersensitivity reactions                                                                 | Corticosteroids<br>Physiologic stress                                                                                                                                                                                              |
| Basophils   | Early inflammatory responses associated with histamine release<br>Anaphylactic reaction<br>Induced molting<br>Severe and prolonged stress | —                                                                                                                                                                                                                                  |
| Platelets   | —                                                                                                                                         | Vitamin K deficiency<br>Rodenticide toxicity<br>Aflatoxicosis<br>Circovirus-associated thrombocytopenia<br>Conure bleeding syndrome<br>Septicemia-associated DIC (as with polyomavirus and reovirus)<br>Hepatic disease or failure |

TABLE 5-31 Quick Reference to Abnormalities of the Standard Avian Biochemical Profile.<sup>a</sup>[272](#),[329](#),[398](#),[482](#)

| Parameter             | Increases                                                                          |                                                                                                                                           | Decreases                                                    |                                                                                                                                       |
|-----------------------|------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------|
|                       | Nonmedical                                                                         | Medical                                                                                                                                   | Nonmedical                                                   | Medical                                                                                                                               |
| ALP (U/L)             | Juveniles have higher levels                                                       | Hyperparathyroidism induced osteoclastic activity (fractures); egg laying; hepatic disease; enteritis; aflatoxicosis                      | —                                                            | Dietary zinc deficiency                                                                                                               |
| ALT (U/L)             | Seasonal variation in raptors; sample hemolysis                                    | —                                                                                                                                         | Seasonal variation in raptors                                | —                                                                                                                                     |
| Amylase (U/L)         | —                                                                                  | Pancreatitis; gastrointestinal disease; zinc toxicity                                                                                     | —                                                            | —                                                                                                                                     |
| AST (U/L)             | Rare; severe lipemia; 300-1000                                                     | Liver, muscle, or heart damage; vitamin E/selenium, methionine deficiency; 300-15,000                                                     | —                                                            | <50; end-stage liver disease                                                                                                          |
| Bile acids (μmol/L)   | Lipemia; sample hemolysis, such samples should not be analyzed                     | Loss of liver function, even with normal enzymes                                                                                          | Lipemic samples that are chemically treated                  | Response to therapy; liver cirrhosis; microhepatica                                                                                   |
| Calcium (mg/dL)       | Lipemia (or cloudy from other causes); protein elevations; bacterial contamination | Hormonal disorders; egg production; metabolic disease; excess dietary vitamin D; dehydration; osteolytic neoplasia                        | EDTA; bacterial contamination; young birds have lower levels | <8; metabolic and nutritional disorders; lead poisoning; glucocorticoid administration; low albumin; African grey parrot hypocalcemia |
| Cholesterol (mg/dL)   | Postprandial; <sup>100</sup> high fat diet; carnivorous diet                       | Metabolic disease; hepatic lipodosis; bile duct obstruction; hypothyroidism; starvation                                                   | —                                                            | Liver, metabolic disease                                                                                                              |
| CK (U/L)              | >300; healthy birds up to 1000                                                     | 600-25,000; muscle or heart damage; CNS disease (seizures); vitamin E/selenium deficiency; chlamydophilosis; lead toxicity; IM injections | <10; bacterial contamination                                 | Rare                                                                                                                                  |
| Creatinine (mg/dL)    | —                                                                                  | Not useful in birds                                                                                                                       | —                                                            | Not useful in birds                                                                                                                   |
| Glucose (mg/dL)       | Improper dilution; postprandial; posthandling                                      | Stress, 400-600; diabetes, 800-1500; corticosteroids                                                                                      | <100; unseparated blood; bacterial contamination             | <100; hepatic dysfunction; septicemia; neoplasia; aspergillosis                                                                       |
| LDH (U/L)             | Sample hemolysis                                                                   | 300-15,000; liver, heart, or muscle damage; hepatitis; muscle damage                                                                      | <50                                                          | End-stage liver disease                                                                                                               |
| Lipase (U/L)          | —                                                                                  | Acute pancreatitis                                                                                                                        | —                                                            | —                                                                                                                                     |
| Phosphorus (mg/dL)    | Postprandial; sample hemolysis                                                     | Severe renal disease; nutritional secondary hyperparathyroidism; hypoparathyroidism                                                       | EDTA                                                         | Hypovitaminosis D; malabsorption; chronic glucocorticoid therapy                                                                      |
| Potassium (mEq/L)     | Hemolysis; dietary supplementation                                                 | Adrenal disease; metabolic disease; severe tissue damage; renal disease; acidosis; dehydration; hemolytic anemia                          | —                                                            | Adrenal disease; metabolic disease; diuretic therapy; alkalosis; overhydration; dietary deficiency                                    |
| Protein, total (g/dL) | Lipemia; non-temperature compensated refractometer                                 | Inflammation; dehydration; chronic infection; gamma globulinopathy; lymphoproliferative disease; myelosis                                 | Non-temperature compensated refractometer                    | Chronic hepatopathy; malabsorption; renal disease; blood loss; neoplasia; starvation/malnutrition                                     |

*Continued*

| Parameter                    | Increases                                                                   |                                                                                                          | Decreases                                           |                              |
|------------------------------|-----------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------|-----------------------------------------------------|------------------------------|
|                              | Nonmedical                                                                  | Medical                                                                                                  | Nonmedical                                          | Medical                      |
| Sodium (mEq/L)               | Dietary supplementation                                                     | Dehydration; salt poisoning                                                                              | —                                                   | Renal disease; overhydration |
| Sorbitol dehydrogenase (U/L) | —                                                                           | Hepatitis                                                                                                | —                                                   | —                            |
| Uric acid (mg/dL)            | 5-15; severe lipemia; dirty nail clip; carnivorous birds have higher levels | Renal disease; gout; dehydration; postprandial; ovulation; tissue damage; starvation; hypervitaminosis D | Overhydration of patient; juvenile levels are lower | End-stage liver disease      |

<sup>a</sup>The ranges given are not absolute and are to be used as a guide for interpretation of a wide range of avian species.

TABLE 5-32 Approximate Resting Respiratory Rates of Selected Avian Species and by Weight. [149,263,695](#)

| Species       | Respiratory Rate (breaths/min) <sup>a</sup> |
|---------------|---------------------------------------------|
| Finch         | 90-110                                      |
| Canary        | 60-80                                       |
| Budgerigar    | 60-75                                       |
| Lovebird      | 50-60                                       |
| Cockatiel     | 40-50                                       |
| Small conure  | 40-50                                       |
| Large conure  | 30-45                                       |
| Toucan        | 15-45                                       |
| Amazon parrot | 15-45                                       |
| Cockatoo      | 15-40                                       |
| Macaw         | 20-25                                       |
| Raptor        | 10-20                                       |
| Weight (g)    | Respiratory Rate (breaths/min) <sup>a</sup> |
| 100           | 40-52                                       |
| 200           | 35-50                                       |
| 300           | 30-45                                       |
| 400           | 25-30                                       |
| 500           | 20-30                                       |
| 1000          | 15-20                                       |

<sup>a</sup> Restraint can increase respiratory rate 1.5-2× resting rate.

TABLE 5-33 T<sub>4</sub> Values of Selected Avian Species. [a,387,473,480,818,871](#)

|  |  |  |
|--|--|--|
|  |  |  |
|--|--|--|

| Species              | Baseline T <sub>4</sub> (nmol/L) <sup>b</sup> | Post-TSH (nmol/L) <sup>c,d</sup> |
|----------------------|-----------------------------------------------|----------------------------------|
| African grey parrot  | 3.83-27.03 <sup>387,818</sup>                 | —                                |
|                      | 1.83 ± 0.57 <sup>473</sup>                    | 11.97 ± 3.73 <sup>473</sup>      |
|                      | ≤1.93 <sup>871</sup>                          | 23.04 ± 13.26 <sup>871</sup>     |
| Amazon parrot        | 1.29-14.16 <sup>387,818</sup>                 | —                                |
|                      | 10.54 ± 8.88 <sup>473</sup>                   | 35.26 ± 20.5 <sup>473</sup>      |
|                      | 5.53 ± 0.36 (red-lored) <sup>871</sup>        | 78.64 ± 44.79 <sup>871</sup>     |
|                      | ≤1.93 (blue-fronted) <sup>871</sup>           | 98.33 ± 26.38 <sup>871</sup>     |
| Budgerigar           | 6.44-27.03 <sup>387,818</sup>                 | —                                |
| Canary               | 9.01-41.18 <sup>387,818</sup>                 | —                                |
| Cockatiel            | 9.01-30.89 <sup>387,818</sup>                 | —                                |
|                      | 15.24 ± 8.7 <sup>473</sup>                    | 50.19 ± 7.28 <sup>473</sup>      |
| Cockatoo             | 17.54 ± 8.4 <sup>473</sup>                    | 45.17 ± 16.94 <sup>473</sup>     |
| Conure               | 6.44-25.74 <sup>387,818</sup>                 | —                                |
|                      | 2.27 ± 0.99 <sup>473</sup>                    | 17.37 ± 9.92 <sup>473</sup>      |
| Eclectus parrot      | 3.86-25.74 <sup>818</sup>                     | —                                |
| Jardine's parrot     | 2.57-19.31 <sup>818</sup>                     | —                                |
| Lory                 | 3.86-15.44 <sup>818</sup>                     | —                                |
| Lovebird             | 2.57-55.34 <sup>387,818</sup>                 | —                                |
| Macaw, blue and gold | 4.39 ± 2.29 <sup>473</sup>                    | 15.91 ± 8.16 <sup>473</sup>      |
| Macaw, scarlet       | 1.72 ± 0.66 <sup>473</sup>                    | 8.31 ± 3.99 <sup>473</sup>       |
| Pigeon               | 6.05-35.01 <sup>387,480,818</sup>             | —                                |
| Pionus parrot        | 6.44-24.45 <sup>818</sup>                     | —                                |
| Quaker parrot        | 5.15-27.03 <sup>818</sup>                     | —                                |
| Senegal parrot       | 6.44-29.6 <sup>818</sup>                      | —                                |

<sup>a</sup> 0.5 µg/dL = 6.5 nmol/L = 5 ng/mL<sup>298</sup> To convert thyroxine from µg/dL to nmol/L multiply by 12.87.<sup>480</sup>

<sup>b</sup> T<sub>4</sub> levels will vary with the time of day and year with higher levels measured in the winter. Physiologic states such as molting or reproductive activity may also alter the ratio of T<sub>4</sub> to T<sub>3</sub> released. The half-life of thyroid hormones is much shorter in birds than in mammals, therefore it is difficult to accurately measure single hormone levels.<sup>522</sup>



<sup>c</sup> The canine radioimmunoassay (RIA) kit does not accurately measure total T<sub>4</sub> below 6.5 nmol/L.<sup>[298](#)</sup> Results of high sensitivity total T<sub>4</sub> testing in parrots ranged from 2-6 nmol/L. This high sensitivity test is available through the University of Tennessee Clinical Endocrinology Laboratory (865-974-5638).<sup>[297](#)</sup>

<sup>d</sup> Low dose TSH (0.2 U/kg).

TABLE 5-34 Urinalysis Values Reported in Birds.<sup>[86,607](#)</sup>

| Parameter               | Reference Range   | Comments                                                                                          |
|-------------------------|-------------------|---------------------------------------------------------------------------------------------------|
| Specific gravity (g/mL) | 1.005-1.020       | —                                                                                                 |
| pH                      | 6.4-8.0           | Laying hens and carnivorous birds may have more acidic urine; cloacal contents may alter urine pH |
| Protein                 | Negative to trace | —                                                                                                 |
| Glucose                 | Negative to trace | —                                                                                                 |
| Ketones                 | Negative          | Ketonuria is sometimes present in migratory birds                                                 |
| Bilirubin               | Negative          | —                                                                                                 |
| Urobilinogen            | Negative          | —                                                                                                 |

TABLE 5-35 Values Reported for Selected Ophthalmic Diagnostic Tests in Avian Species.<sup>[155,356,385,448,628,771](#)</sup>

| Species                             | Ultrasound<br>(cm ± STD) | Schirmer<br>Tear Test<br>(mm) | Intraocular Pressure<br>(mm Hg) |                      | Phenol Red Thread Test<br>(mm/15 sec ± STD) |                             |
|-------------------------------------|--------------------------|-------------------------------|---------------------------------|----------------------|---------------------------------------------|-----------------------------|
|                                     |                          |                               | Applanation<br>Tonometry        | Rebound<br>Tonometry | OS                                          | OD                          |
| Bald eagle                          | —                        | —                             | 20.6 ± 2                        | —                    | —                                           | —                           |
| Blue-fronted<br>Amazon <sup>b</sup> | —                        | —                             | —                               | —                    | —                                           | —                           |
| D1                                  | 0.17 ± 0.03              | —                             | —                               | —                    | —                                           | —                           |
| D2                                  | 0.35 ± 0.02              | —                             | —                               | —                    | —                                           | —                           |
| D3                                  | 0.73 ± 0.04              | —                             | —                               | —                    | —                                           | —                           |
| Axial length                        | 1.26 ± 0.06              | —                             | —                               | —                    | —                                           | —                           |
| Chicken,<br>3-week old              | —                        | —                             | —                               | 17.5 ± 0.1           | —                                           | —                           |
| Golden<br>eagle                     | —                        | —                             | 21.5 ± 3                        | —                    | —                                           | —                           |
| Great<br>horned owl                 | —                        | —                             | 10.8 ± 3.6                      | —                    | —                                           | —                           |
| Eurasian<br>eagle owl               | —                        | —                             | —                               | 10.5 ± 1.6           | —                                           | —                           |
| Large<br>psittacines <sup>c</sup>   | —                        | —                             | —                               | —                    | 19.1 ±<br>3.3-25.5<br>± 5.2                 | 19.8 ±<br>4.3-28.2<br>± 6.3 |
| Red-tailed<br>hawk                  | —                        | —                             | 20.6 ± 3.4                      | —                    | —                                           | —                           |
| Swainson's<br>hawk                  | —                        | —                             | 20.8 ± 2.3                      | —                    | —                                           | —                           |
| Tawny owl,<br>juvenile              | —                        | 7.2                           | —                               | —                    | —                                           | —                           |
| Tawny owl,<br>adult                 | —                        | 4.3                           | 9.4 ± 1.8                       | —                    | —                                           | —                           |

<sup>a</sup>Mean values reported.

<sup>b</sup>Transpalpebral ocular ultrasound examinations were performed on 32 blue-footed Amazon parrots (*Amazona aestiva*) with no history of ocular disease; measurements were taken in sagittal planes using a 10 MHz linear probe without a standoff pad; D1 is the distance between the cornea and the anterior lens capsule; D2 is the distance between the anterior and posterior lens capsule; D3 is the distance between the posterior lens capsule and the optic papilla.<sup>445</sup>

<sup>c</sup>Group of large parrots including 22 macaws, 17 cockatoos, 10 Amazons, 1 African grey, 1 eclectus, and 1 pionus.<sup>356</sup>

TABLE 5-36 Checklist of Supportive Care Procedures Used in Companion Bird Medicine.<sup>83</sup>

|                                                                       |
|-----------------------------------------------------------------------|
| Supportive care is an essential component of companion bird medicine. |
| 1. Minimize handling and other stressors                              |
| 2. House the bird in a warm, quiet, well-ventilated environment       |

- Ensure minimal to no disturbance
- Debilitated birds are often fluffed and ruffled and require supplemental heat 86°F (30°C)

### 3. Fluid therapy<sup>766</sup>

- Warm fluids to 100-102°F (38-39°C) to help prevent or correct hypothermia
- Daily maintenance requirements are estimated at 50 mL (range: 40-60 mL)/kg/day in many birds (the smallest passerines drink 250-300 mL/kg/day)<sup>494</sup>
- The route of fluid administration (PO, SC, IV, and/or IO) will vary with the clinical case
- When giving an IV or IO bolus, administer up to 10 mL/kg, ideally over a 5-10 minute period
- Up to 50 mL/kg may be given orally via gavage or feeding tube; begin with ½ to ⅓ of this estimated crop volume
- A combination of routes is recommended if large fluid volumes are administered
- Hetastarch at 10-15 mL/kg IV q8h for up to 4 treatments or dextrans may be effective for hypoproteinemia (use synthetic colloids with caution in patients with congestive heart failure or renal failure)<sup>774</sup>

### 4. Provide analgesia when indicated (see [Tables 5-5](#) and [5-6](#))

### 5. Supplement vitamins as needed

- Vitamin A, vitamin E/selenium
- Vitamin B complex in selected cases of injury, anorexia, cachexia, CNS disorders, or blood loss

### 6. Antibiotics (see [Table 5-1](#))

- To control primary infections and for injured or debilitated birds where secondary infections may result

### 7. Iron dextran

- Iron deficiency or following hemorrhage

### 8. Normal photoperiod (or subdued lighting, if needed)

### 9. Oxygen

- Dyspnea, hypoxia, or severe pneumonia and air sacculitis

### 10. Maintain body weight

- Weigh once or twice daily if possible
- Offer favorite foods and avoid changing diet while ill

### 11. Gavage or tube feeding<sup>a</sup>

- Malnourishment, anorexia, cachexia, and dehydration
- High carbohydrate formula is initially recommended

- High protein/high calorie formulas may be used to increase body weight during recovery

12. Corticosteroids (use with caution because of immunosuppressive effects, etc.) in cases of:

- Extreme stress
- CNS trauma
- Selected toxemias and intoxications

<sup>a</sup> Crop volume may be estimated as 5% BW or 50 mL/kg.

## TABLE 5-37 Fluid Therapy Recommendations for Birds.

When evaluating a patient for fluid therapy, the following factors should ideally be considered: hydration status, electrolyte balance, acid-base status, hematologic and biochemical values, and caloric balance.

- Warm fluids to 100-102°F (38-39°C) to help prevent or correct hypothermia
- Use caution when giving dextrose parenterally; 5% dextrose is a good choice for simple dehydration, however it can exacerbate problems significantly if used concurrent to significant electrolyte loss<sup>507,766</sup>
- When given orally, dextrose is rapidly absorbed from the intestinal tract without creating an influx of fluid into the intestinal lumen and secondary dehydration<sup>507,766</sup>
- Potassium chloride can be diluted in fluids to correct for potassium depletion based on electrolyte analysis (0.1-0.3 mEq/kg)<sup>812</sup>
- Hetastarch at 10-15 mL/kg IV q8h for up to 4 treatments or dextrans may be effective for hypoproteinemia; synthetic colloids should be used with caution in patients suffering from congestive heart failure or renal failure<sup>537,774</sup>

Total parenteral nutrition may also be considered.<sup>177,178</sup>

### **Maintenance and Deficit Replacement**<sup>363,537,634,696</sup>

- Determine fluid deficit:

$$\text{Fluid deficit (mL)} = \text{body weight (g)} \times \% \text{ dehydration}$$

- Determine daily maintenance:

Daily maintenance is estimated at 50 mL (range: 40-60 mL/kg/day in many avian species); the smallest passerines drink 250-300 mL/kg daily.<sup>494</sup>

- If possible, replace 50% of the deficit in the first 12-24 hr, and the remainder over the next 24-48

hr; some clinicians recommend replacing 20-25% of the deficit in the first 4-6 hr, and the remaining volume during the next 24-72 hr

TABLE 5-38 Routes of Administration and Maximum Suggested Volumes of Fluids Which Can Be Administered to Psittacines. [328,652,766](#)

| Route                             | Maximum Suggested Volume of Fluid <sup>a</sup>                                                                                                                                                                                                                                                |
|-----------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Gavage                            | <ul style="list-style-type: none"><li>• Administer up to 5 mL/100 g bird<sup>b</sup></li><li>• Initial volume should be much less in critically ill and anorectic patients (begin with ½ to ⅓ of estimated crop volume)</li><li>• Crop volume may be up to 10% BW in neonatal birds</li></ul> |
| Intravenous or intraosseous bolus | Administer up to 10 mL/kg (ideally over a 5-10 min period)                                                                                                                                                                                                                                    |
| Subcutaneous                      | 50 mL/kg <sup>c,d</sup>                                                                                                                                                                                                                                                                       |

<sup>a</sup> Combinations of routes (PO, SC, and IV/IO) are recommended if large fluid volumes are administered.

<sup>b</sup> Crop volume may be estimated at 5% of body weight (BW).

<sup>c</sup> Volumes of 10-15 mL/kg may be comfortably given per subcutaneous injection site, although up to 25 mL/kg per site may be given. Overdistension of the area may compromise blood supply to the area and reduce absorption. [766](#)

<sup>d</sup> Hyaluronidase (Wydase, Wyeth-Ayerst) (1 mL (150 U)/L fluids) may be used in most species to increase the absorption rate of fluids. [399](#)

TABLE 5-39 Suggested Volumes and Frequency of Gavage Feeding in Anorectic Birds. [634,696](#)

| Species    | Volume (mL) <sup>a,b</sup> | Frequency <sup>a</sup> |
|------------|----------------------------|------------------------|
| Finch      | 0.1-0.5                    | q4h                    |
| Budgerigar | 0.5-3                      | q6h                    |
| Lovebird   | 1-3                        | q6h                    |
| Cockatiel  | 1-8                        | q6h                    |

|               |       |        |
|---------------|-------|--------|
| Conure, small | 3-12  | q6h    |
| Conure, large | 7-24  | q6-8h  |
| Amazon parrot | 5-35  | q8h    |
| Cockatoo      | 10-40 | q8-12h |
| Macaw         | 20-60 | q8-12h |

<sup>a</sup> Adjust volume and frequency as crop accommodates larger volumes.

<sup>b</sup> Generally 3-5% of body weight.[327](#)

TABLE 5-40 Calculation of Enteral Feeding Requirements for Birds.[629](#)

When dealing with a debilitated patient that must be tube fed more than once or twice, it is always prudent to make sure you are meeting its caloric requirements.

Basal metabolic rate (BMR) (kcal/day) =  $kW^{0.75}$

Maintenance energy requirements (MER) (kcal/day) = (1.5 × BMR)

$k$  = kcal/kg/day constant (nonpasserines = 78, passerines = 129)

- Calculate MER
- Adjust the MER value for debilitated patients, taking their specific clinical condition into account.

For instance, an adjustment for sepsis is made by multiplying by 1.5.

Most manufacturers of critical care diets provide information on caloric content (see below); if they do not, call them and ask (see Table 5-42).

| Product<br>(Manufacturer)                           | Protein (%)          |                     | Fat (%)              |                     | Fiber (%)            |                     | CHO (NFE) (%)<br>Dry Matter Basis | Caloric<br>Content (kcal) |
|-----------------------------------------------------|----------------------|---------------------|----------------------|---------------------|----------------------|---------------------|-----------------------------------|---------------------------|
|                                                     | Label Claim<br>(min) | Dry Matter<br>Basis | Label Claim<br>(min) | Dry Matter<br>Basis | Label Claim<br>(max) | Dry Matter<br>Basis |                                   |                           |
| a/d Canine/Feline<br>Critical Care (Hill's)         | 8.5                  | 44.2                | 6.6                  | 30.4                | 0.5                  | 1.3                 | 15.4                              | 1.3/mL                    |
| Carnivore Care<br>(Oxbow)                           | 45                   | —                   | 32                   | —                   | 3                    | —                   | —                                 | 0.8/mL <sup>a</sup>       |
| CliniCare Canine/<br>Feline Liquid Diet<br>(Abbott) | 8.2                  | 35.1                | 5.1                  | 22.2                | 0.1                  | 0.4                 | 29.5                              | 1/mL                      |
| Emeraid Carnivore<br>(Lafeber)                      | 37.8                 | —                   | 34                   | —                   | 4.5                  | —                   | —                                 | 2.1                       |
| Emeraid Herbivore<br>(Lafeber) <sup>a</sup>         | 19                   | —                   | 9.5                  | —                   | 32                   | —                   | —                                 | 1.2/mL                    |

|                                               |      |   |     |   |     |   |   |          |
|-----------------------------------------------|------|---|-----|---|-----|---|---|----------|
| Emerald Omnivore (Lafeber)                    | 20   | — | 9.5 | — | 0.5 | — | — | 2        |
| Emerald Nutri-Support (Lafeber)               | 18.5 | — | 5   | — | 1   | — | — | 2.5      |
| Exact Baby Bird Hand Feeding Formula (Kaytee) | 22   | — | 9   | — | 5   | — | — | 3.9/g    |
| Exact Macaw Hand Feeding Formula (Kaytee)     | 19   | — | 13  | — | 5   | — | — | 4.1/g    |
| Formula AA Acute Care (Roudybush)             | 20   | — | 10  | — | 5   | — | — | 3.5/g DW |
| Maximum-Calorie Veterinary Formula (Jams)     | 14   | — | 12  | — | 1   | — | — | 2.1/mL   |
| Recovery Formula (Harrison's)                 | 35   | — | 19  | — | 1   | — | — | 3.9/g    |

\*Carbohydrate nitrogen-free extract.  
 †24 kcal/Tbs of powder.  
 ‡Fed in combination with Emerald Omnivore to geese and swans.

TABLE 5-41 Doxycycline Recipes Used in Psittacines.[243,626](#)

|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <p><b>Medicated water for cockatiels:</b></p> <ol style="list-style-type: none"> <li>1. Mix doxycycline with tap water to a final concentration of 280 mg/L (0.28 mg/mL) using a magnetic stir bar and plate</li> <li>2. Prepare daily for 45 days</li> <li>3. No calcium supplementation should be provided</li> </ol> <p><b>Medicated seed for cockatiels:</b></p> <ol style="list-style-type: none"> <li>1. Combine 60% hulled millet and 40% hulled sunflower seed with 6.25 mL sunflower oil/kg seed; mix well</li> <li>2. Mix doxycycline with seeds at 500 mg/kg wet weight using an electric mixer</li> <li>3. Prepare daily for 45 days</li> <li>4. No calcium supplementation should be provided</li> </ol> <p><b>Medicated seed for budgerigars:</b></p> <ol style="list-style-type: none"> <li>1. Create a 1:4 mixture of hulled oat groat and hulled millet</li> <li>2. Mix well</li> <li>3. Add approximately 6 mL sunflower oil/kg seed (enough to coat seeds, but not dripping)</li> <li>4. Mix well</li> <li>5. Add the contents of doxycycline hyclate capsules aseptically (300 mg drug/kg seed)</li> <li>6. Prepare daily for 45 days</li> <li>7. No calcium supplementation should be provided</li> </ol> |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|

TABLE 5-42 Selected Sources of Formulated and Medicated Diets for Companion and Aviary Birds.

|                                                                              |
|------------------------------------------------------------------------------|
| Avi-Sci, Inc <sup>a</sup>                                                    |
| 4477 South Williams Road                                                     |
| St. Johns, MI 48879, USA                                                     |
| Phone: 800-942-3438                                                          |
| Fax: 989-224-9227                                                            |
| <a href="http://www.avi-sci.com">www.avi-sci.com</a>                         |
| Harrison's Bird Foods                                                        |
| 7108 Crossroads Blvd, Suite 325 Brentwood, TN 37027, USA                     |
| Phone: 800-346-0269                                                          |
| Fax: 615-221-9898                                                            |
| <a href="http://www.harrisonsbirdfoods.com/">www.harrisonsbirdfoods.com/</a> |
| Kaytee Products, Inc                                                         |
| 521 Clay St, PO Box 230                                                      |
| Chilton, WI 53014, USA                                                       |
| Phone: 800-669-9580                                                          |
| Fax: 920-849-7044                                                            |
| <a href="http://www.kaytee.com/">www.kaytee.com/</a>                         |
| Lafeber Co                                                                   |
| 24981 N 1400 East Rd                                                         |
| Cornell, IL 61319, USA                                                       |
| Phone: 800-842-6445                                                          |
| Fax: 815-358-2352                                                            |
| <a href="http://www.lafebervet.com/">www.lafebervet.com/</a>                 |
| Lake's Unlimited, Inc                                                        |
| 639 Stryker Ave                                                              |
| St Paul, MN 55107, USA                                                       |
| Phone: 800-634-2473                                                          |
| Fax: 651-290-7650                                                            |
| <a href="http://www.lakesbirdfood.com/">www.lakesbirdfood.com/</a>           |
| L'Avian Plus                                                                 |
| D & D Commodities Ltd.                                                       |
| PO Box 359                                                                   |
| Stephen, MN 56757, USA                                                       |



Phone: 800-543-3308

[www.lavianplus.com/LAP/](http://www.lavianplus.com/LAP/)

Mazuri Diets

PMI Nutrition International LLC

PO Box 66812

St Louis, MO 63166-6812, USA

Phone: 800-227-8941

[www.mazuri.com/](http://www.mazuri.com/)

Pretty Bird International, Inc<sup>a</sup>

31008 Fox Hill Ave

Stacy, MN 55079, USA

Phone: 800-356-5020

Fax: 651-462-1844

[www.prettybird.com/](http://www.prettybird.com/)

Rolf C. Hagen, Inc<sup>a</sup>

50 Hampden Rd

Mansfield, MA 02048, USA

Phone: 800-724-2436

Fax: 508-339-6973

[www.hagen.com/usa/index.html](http://www.hagen.com/usa/index.html)

Roudybush Foods<sup>a</sup>

340 Hanson Way

Woodland, CA 95776, USA

Phone: 800-326-1726

Fax: 888-276-8222

[www.roudybush.com/](http://www.roudybush.com/)

Scenic Bird Food

Marion Zoological

2003 E. Center Circle

Plymouth, MN 55441, USA

Phone: 800-327-7974

Fax: 763-559-0789

[www.scenicbirdfood.com/](http://www.scenicbirdfood.com/)

Zeigler Bros, Inc<sup>a</sup>

PO Box 95

Gardners, PA 17324, USA

Phone: 800-841-6800

|                                                                          |
|--------------------------------------------------------------------------|
| Fax: 717-677-6826                                                        |
| <a href="http://www.zeiglerfeed.com/html/">www.zeiglerfeed.com/html/</a> |
| ZuPreem Diets                                                            |
| Premium Nutritional Products, Inc                                        |
| PO Box 2094                                                              |
| Mission, KS 66201, USA                                                   |
| Phone: 800-345-4767                                                      |
| Fax: 913-962-1286                                                        |
| <a href="http://www.zupreem.com/">www.zupreem.com/</a>                   |

<sup>a</sup> Source of medicated feeds.

TABLE 5-43 Selected Nutritional Recommendations for Wild Bird Rehabilitation. [a,90,212,217,264,735](#)

| Aquatic Birds, Including Wading Birds and Seabirds                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <ul style="list-style-type: none"> <li>• Live-prey eating birds like pelicans and herons may not recognize familiar food in an unfamiliar presentation; offer live fish in large tubs, such as a small child’s pool, but be prepared to force-feed as needed.</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| Hummingbirds                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
| <ul style="list-style-type: none"> <li>• It is extremely challenging to meet the nutritional needs of hummingbirds; hummingbirds must constantly replenish energy sources to survive; nectar from plants as well protein from insects (an estimated 100 mg) are both critical daily dietary requirements.</li> <li>• Nektar-Plus (Nekton) will provide adequate nutritional support, including protein.</li> <li>• Insects, such as <i>Drosophila</i> fruit flies, may be released into the enclosure.<a href="#">588</a></li> </ul>                                                                                                                                                                                                                                         |
| Raptors                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| <ul style="list-style-type: none"> <li>• Rehydrate first (see <a href="#">Table 5-37</a> and <a href="#">5-38</a>); this is particularly important in birds of prey, because the raptor’s digestive process requires copious secretions.</li> <li>• For debilitated birds, tube feed a diet rich in protein and fat; offer an enteral tube feeding product (see <a href="#">Table 5-40</a>), ground whole prey (less feet, fur or feathers, gastrointestinal tract), or small amounts of quail breast meat soaked in oral electrolytes.</li> <li>• Feed whole prey after establishing normal gastrointestinal time; offer food the bird will recognize as prey such as eviscerated fish, rats, mice, and/or quail; to increase the chances of self-feeding, offer</li> </ul> |

a variety of foods.

- Feed juvenile raptors a whole animal diet of mice or rats supplemented with vitamins; for young nestlings, remove the fur, toenails, and the gastrointestinal tract, then dice the remainder of the body to create a fine “mush”.

**Songbirds**

- Determine if the bird is an omnivore, herbivore, nectarivore, or insectivore and offer a variety of foods; use a good identification book like *The Sibley Guide to Birds*<sup>735</sup> paired with a resource like *The Birder’s Handbook*<sup>212</sup> to determine preferred foods.
- Offer a variety of foods, such as high-quality birdseed, mealworms, and tiny pieces of fresh fruit and vegetables, in a shallow container or lid.
- Presentation of food promotes self-feeding; place earthworms in a pan of soil for thrushes, offer berries still attached to a branch to a mockingbird.
- Swifts and swallows may take a live insect on a forcep.
- Woodpeckers may eat mealworms trapped in peanut butter spread on bark.

**Waterfowl**

- Offer domestic waterfowl, mallard ducks, and Canada geese cracked corn, scratch grains, leafy greens, and non-medicated waterfowl or poultry diet.
- Swans, particularly trumpeter swans, may refuse to eat for 3 or more days; place the swan in an isolated area, with a slurry of food and fresh greens; do not disturb unless absolutely necessary.
- Offer water in a dish or bucket deep enough to allow the bird to submerge its entire neck before its bill touches the bottom of the container.
- Do not use galvanized metal containers as the zinc may leach into food and water.
- For ducklings, goslings, and cygnets, offer non-medicated waterfowl or chick starter in shallow dishes and scattered on the floor of the enclosure.
- Tiny pieces of bright fruit, like strawberries, or small, live mealworms may stimulate self-feeding in a hospital setting.

<sup>a</sup> See [Tables 13-1](#), [13-6](#), and [13-7](#) for more details.

TABLE 5-44 Management of Egg Retention in Birds.<sup>81,462</sup>

| Definitions                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <ul style="list-style-type: none"><li>• Dystocia—obstruction of the oviduct by the developing egg</li><li>• Egg binding—delay in rate of passage of an egg through the oviduct</li></ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| Etiology—Often Multifactorial                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
| <ul style="list-style-type: none"><li>• Nutritional: hypocalcemia, low protein diets, hypovitaminosis E, and/or general malnutrition</li><li>• Egg-related: abnormal egg shape or position, abnormally large egg, inadequately or soft-shelled egg</li><li>• Hen-related: pelvic injury, salpingitis, systemic disease, oviduct scarring from previous dystocia or surgery, infection, and/or neoplasia</li></ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
| Diagnosis                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| <ul style="list-style-type: none"><li>• History/clinical signs/physical findings: non-specific signs of illness, tachypnea, persistent tail bobbing, ± blood from vent or in droppings, coelomic distension ± palpable egg</li><li>• Radiography/ultrasonography ± biochemistry panel</li></ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |
| Treatment                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| <ul style="list-style-type: none"><li>• Stabilize the patient<ul style="list-style-type: none"><li>• Administer warmed fluids, SC, IV, or IO</li><li>• Dextrose: 50% bolus IV or IO; 2.5% in fluids SC</li><li>• Warm, dark, humidified environment</li><li>• Nutritional support required in most cases</li><li>• Calcium gluconate: 50-100 mg/kg IM or IV (slow)</li><li>• Vitamins: 10,000 U vitamin A and 1000 U vitamin D<sub>3</sub>/300 g BW IM</li></ul></li><li>• Medical management<ul style="list-style-type: none"><li>• Oxytocin: 5 U/kg IM, may repeat q30min</li><li>• Prostaglandin E<sub>2</sub>: 0.1 mL/100 g (1 mL/kg) intracloacal on uterine sphincter</li></ul></li><li>• Surgical management<ul style="list-style-type: none"><li>• Attempt after 12-24 hr unless patient is obstructed, then attempt sooner</li><li>• General anesthesia must be used</li><li>• Use caution when manipulating egg; do not press cranially when stabilizing the egg, as this will compromise respiration</li><li>• Manual expression: gentle digital pressure to direct egg caudally</li><li>• Cloacal ovocentesis</li></ul></li></ul> |

- 18-ga needle regardless of patient size
- Visualize egg/oviductal opening using lubricated speculum or cotton applicators and focal light source
- Insert needle into egg and aspirate contents while stabilizing egg
- Gently implode egg with digital pressure
- Extract fragments with curved hemostats
- Percutaneous ovocentesis
  - 18-ga needle
  - Stabilize egg against left side of body, then aseptically prepare area
  - Insert needle and aspirate contents
  - Gently implode egg with digital pressure
  - Maintain hydration to promote passage of egg shell fragments
- Salpingohysterectomy or salpingotomy

TABLE 5-45 Protocols Used in Treating Mycobacteriosis in Birds.<sup>a,b</sup>

| Agent          | Drug Combinations and Dosages |                  |                  |                  |                  |                        |                  |                        |                  |                               |
|----------------|-------------------------------|------------------|------------------|------------------|------------------|------------------------|------------------|------------------------|------------------|-------------------------------|
|                | 1                             | 2                | 3                | 4                | 5                | 6                      | 7                | 8                      | 9                | 10                            |
| Azithromycin   | —                             | —                | —                | —                | —                | —                      | —                | 45 mg/kg PO q24h       | —                | 43 mg/kg PO q24h              |
| Ciprofloxacin  | —                             | —                | —                | —                | 80 mg/kg PO q24h | —                      | —                | —                      | —                | 15 mg/kg PO q12h <sup>c</sup> |
| Clarithromycin | —                             | —                | —                | —                | —                | —                      | 55 mg/kg PO q24h | 85 mg/kg PO q24h       | —                | —                             |
| Clotazimine    | —                             | —                | —                | —                | —                | 1.5 mg/kg PO q24h      | —                | —                      | 6 mg/kg PO q24h  | —                             |
| Cycloserine    | —                             | —                | —                | —                | —                | 5 mg/kg PO q12h        | —                | —                      | —                | —                             |
| Enrofloxacin   | —                             | —                | 30 mg/kg PO 24h  | 30 mg/kg PO q24h | —                | 10-15 mg/kg PO,IM q12h | 6 mg/kg PO q24h  | —                      | —                | —                             |
| Ethambutol     | 30 mg/kg PO q24h              | 10 mg/kg PO q12h | 30 mg/kg PO q24h | 30 mg/kg PO q24h | 30 mg/kg PO q24h | 20 mg/kg PO q24h       | 30 mg/kg PO q24h | 15-30 mg/kg PO q12-24h | 30 mg/kg PO q24h | 30 mg/kg PO q24h              |
| Isoniazid      | 30 mg/kg PO q24h              | —                | —                | —                | —                | —                      | —                | —                      | —                | —                             |
| Rifabutin      | —                             | —                | 15 mg/kg PO q24h | —                | —                | —                      | 45 mg/kg PO q24h | 15-45 mg/kg PO q24h    | —                | 15 mg/kg PO q24h              |

Continued

Drug Combinations and Dosages

| Agent        | 1                   | 2                   | 3 | 4                   | 5                   | 6 | 7 | 8 | 9                   | 10 |
|--------------|---------------------|---------------------|---|---------------------|---------------------|---|---|---|---------------------|----|
| Rifampin     | 45 mg/kg<br>PO q24h | 15 mg/kg<br>PO q12h | — | 45 mg/kg<br>PO q24h | 45 mg/kg<br>PO q24h | — | — | — | 45 mg/kg<br>PO q24h | —  |
| Streptomycin | —                   | 30 mg/kg<br>IM q12h | — | —                   | —                   | — | — | — | —                   | —  |

<sup>a</sup>Because of its zoonotic potential, controversy exists on whether to treat pet and aviary birds for *Mycobacterium avium*. Because *M. avium* isolates from birds differ from human isolates in antibiotic susceptibility, serovars, and genetic sequencing, pet birds are an unlikely source of *M. avium* in people (except immunosuppressed individuals). Nevertheless, veterinarians who treat birds with this disease do so at their own risk. The veterinarian should be aware that treatment is often lifelong for the bird, and that treatment does not necessarily prevent shedding. <sup>(144), (145), (146), (147)</sup>

<sup>b</sup>Empirical evaluation of multi-drug therapy found that azithromycin (43 mg/kg), rifampin (45 mg/kg), and ethambutol (30 mg/kg) were ineffective in ring-necked doves (*Streptopelia risoria*) naturally infected with avian mycobacteriosis. Culture and sensitivity results indicated resistance to all drugs except for azithromycin. <sup>(148)</sup>

<sup>c</sup>Mix into dextrose powder, administered with a small amount of food. <sup>(149)</sup>

<sup>d</sup>Recommended for use in raptors. <sup>(150)</sup>

<sup>e</sup>Enrofloxacin (15 mg/kg PO q12h), clotacinine (6 mg/kg PO q12h), or amikacin IM, IV can be used in lieu of ciprofloxacin with ethambutol, rifabutin, and azithromycin. <sup>(151)</sup>

TABLE 5-46 Suggested Chemotherapeutic Protocols Used in Birds.

### C.O.P. PROTOCOL FOR LYMPHOSARCOMA<sup>269</sup>

- Prednisone 25 mg/m<sup>2</sup> PO q24h
- Cyclophosphamide 200 mg/m<sup>2</sup> IO q7d
- Vincristine 0.75 mg/m<sup>2</sup> IO q7d × 3 treatments
- Doxorubicin 30 mg/m<sup>2</sup> IO q21d
- L-asparaginase 400 U/kg IM q7d
- Interferon α 15,000 U/m<sup>2</sup> SC q2d × 3 treatments
- Diphenhydramine 2 mg/kg IO before doxorubicin and L-asparaginase treatments
- Dexamethasone 1 mg/kg IM before doxorubicin and L-asparaginase treatments

### PROTOCOL FOR LYMPHOCYTIC LEUKEMIA OR LYMPHOSARCOMA<sup>a,566</sup>

- Vincristine sulfate 0.5 mg/m<sup>2</sup> IV initial dose, then 0.75 mg/m<sup>2</sup> q7d × 3 treatments
- Prednisone 1 mg/454 g PO q12h
- Chlorambucil 1 mg/bird PO 2×/wk

### PROTOCOL FOR CUTANEOUS LYMPHOSARCOMA<sup>b,677</sup>

- Vincristine 0.1 mg/kg IV q7-14d
- Chlorambucil 2 mg/kg PO 2×/wk

### PROTOCOL FOR OSTEOSARCOMA<sup>c,194</sup>

- Diphenhydramine 30 min before doxorubicin treatment (route and dose not given)
- Doxorubicin 60 mg/m<sup>2</sup> is diluted into 6 ml sterile saline and administered IV over 30 min in an anesthetized patient via an angiocatheter in the jugular vein q30d
  - Do not extravasate doxorubicin; doxorubicin may cause myelosuppression and cardiac toxicity; monitor the CBC
- Electrocardiography during treatment is recommended

<sup>a</sup> Dosages are for a Pekin duck (*Anas platyrhynchos domesticus*).

<sup>b</sup> Dosages are for an umbrella cockatoo (*Cacatua alba*).

<sup>c</sup> Dosages are for a blue-fronted Amazon parrot (*Amazona aestiva*).

TABLE 5-47 Cardiopulmonary Resuscitation (CPR) in Birds.<sup>a</sup>

| Emergency Drug                                    | Dose                     | 15 g<br>(Canary;<br>Finch) | 30 g<br>(Budgerigar) | 40-50 g<br>(Lovebird) | 100 g<br>(Conure;<br>Cockatiel) | 200 g<br>(Mynah) | 300 g<br>(Pigeon;<br>Sulphur-<br>crested<br>Cockatoo) | 400 g<br>(African<br>Grey<br>Parrot;<br>Eclectus<br>Parrot) | 500 g<br>(Umbrella<br>Cockatoo) | 750 g<br>(Greater<br>Sulphur-<br>crested<br>Cockatoo) | 1 kg<br>(Blue<br>and Gold<br>Macaw) |
|---------------------------------------------------|--------------------------|----------------------------|----------------------|-----------------------|---------------------------------|------------------|-------------------------------------------------------|-------------------------------------------------------------|---------------------------------|-------------------------------------------------------|-------------------------------------|
| Atropine<br>(0.2-0.5 mg/mL)                       | 0.5 mg/kg                | 0.006-<br>0.015 mL         | 0.012-0.03<br>mL     | 0.015-0.05<br>mL      | 0.04-0.1<br>mL                  | 0.08-0.2<br>mL   | 0.12-0.3<br>mL                                        | 0.16-0.4<br>mL                                              | 0.2-0.5 mL                      | 0.3-0.75<br>mL                                        | 0.4-1 mL                            |
| Calcium gluco-<br>nate (10%)<br>(100 mg/mL)       | 50-100<br>mL/kg          | 0.007-<br>0.015 mL         | 0.015-0.03<br>mL     | 0.02-0.06<br>mL       | 0.05-0.1<br>mL                  | 0.1-0.2 mL       | 0.15-0.3<br>mL                                        | 0.2-0.4<br>mL                                               | 0.25-0.5<br>mL                  | 0.375-0.75<br>mL                                      | 0.5-1 mL                            |
| Dexamethasone<br>sodium<br>phosphate<br>(4 mg/mL) | 2-4<br>mg/kg             | 0.007-<br>0.015 mL         | 0.015-0.03<br>mL     | 0.02-0.06<br>mL       | 0.05-0.1<br>mL                  | 0.1-0.2 mL       | 0.15-0.3<br>mL                                        | 0.2-0.4<br>mL                                               | 0.25-0.5<br>mL                  | 0.375-0.75<br>mL                                      | 0.5-1 mL                            |
| Dextrose (50%)                                    | 1 mL/kg<br>(slow)        | 0.015 mL                   | 0.03 mL              | 0.04-0.05<br>mL       | 0.1 mL                          | 0.2 mL           | 0.3 mL                                                | 0.4 mL                                                      | 0.5 mL                          | 0.75 mL                                               | 1 mL                                |
| Doxapram<br>(20 mg/mL)                            | 20 mg/kg                 | 0.015 mL                   | 0.03 mL              | 0.04-0.06<br>mL       | 0.1 mL                          | 0.2 mL           | 0.3 mL                                                | 0.4 mL                                                      | 0.5 mL                          | 0.75 mL                                               | 1 mL                                |
| Epinephrine<br>(1:1000;<br>1 mg/mL)               | 0.5-1<br>mg/kg           | 0.007-<br>0.015 mL         | 0.015-0.03<br>mL     | 0.02-0.06<br>mL       | 0.05-0.1<br>mL                  | 0.1-0.2 mL       | 0.15-0.3<br>mL                                        | 0.2-0.4<br>mL                                               | 0.25-0.5<br>mL                  | 0.375-0.75<br>mL                                      | 0.5-1 mL                            |
| Fluid (bolus)                                     | 25 mL/kg                 | 0.375 mL                   | 0.75 mL              | 1-1.25 mL             | 2.5 mL                          | 5 mL             | 7.5 mL                                                | 10 mL                                                       | 12.5 mL                         | 18.7 mL                                               | 25 mL                               |
| Hetastarch                                        | 10-15<br>mL/kg<br>(slow) | 0.15-<br>0.225 mL          | 0.3-0.45 mL          | 0.4-0.75<br>mL        | 1-1.5 mL                        | 2-3 mL           | 3-4.5 mL                                              | 4-6 mL                                                      | 5-7.5 mL                        | 7.5-11.25<br>mL                                       | 10-15 mL                            |
| Mannitol (20%)<br>(200 mg/mL)                     | 0.5-2<br>mL/kg           | 0.0075-<br>0.03 mL         | 0.015-0.06<br>mL     | 0.02-0.1<br>mL        | 0.05-0.2<br>mL                  | 0.1-0.4 mL       | 0.15-0.6<br>mL                                        | 0.2-0.8<br>mL                                               | 0.25-1 mL                       | 0.375-1.5<br>mL                                       | 0.5-2 mL                            |
| Prednisolone<br>sodium succi-<br>nate (10 mg/mL)  | 10-20<br>mg/kg           | 0.015-<br>0.03 mL          | 0.03-0.06 mL         | 0.04-0.1<br>mL        | 0.1-0.2 mL                      | 0.2-0.4 mL       | 0.3-0.6 mL                                            | 0.4-0.8<br>mL                                               | 0.5-1 mL                        | 0.75-1.5<br>mL                                        | 1-2 mL                              |
| Prednisolone<br>sodium succi-<br>nate (50 mg/mL)  | 10-20<br>mg/kg           | 0.003-<br>0.006 mL         | 0.006-0.012<br>mL    | 0.008-0.02<br>mL      | 0.02-0.04<br>mL                 | 0.04-0.08<br>mL  | 0.06-0.12<br>mL                                       | 0.08-<br>0.16 mL                                            | 0.1-0.2 mL                      | 0.15-0.3<br>mL                                        | 0.2-0.4<br>mL                       |
| Sodium<br>bicarbonate<br>(1 mEq/mL)               | 5 mEq/kg                 | 0.075 mL                   | 0.15 mL              | 0.2-0.25<br>mL        | 0.5 mL                          | 1 mL             | 1.5 mL                                                | 2 mL                                                        | 2.5 mL                          | 3.75 mL                                               | 5 mL                                |

<sup>a</sup>Dose in mL/kg body weight, IV, IO, or IM. If weight is not available, base CPR on approximate weight of species closest in size.

TABLE 5-48 Vaccines Used in Birds (Non-Poultry). [104,119,323,391,413,486,509,536,578,610,669,675,684,812,861](#)



| Species                   | Agent                                                            | Dosage                                                                                                                                             | Initial                                                                                                           | Booster                                                            | Comments                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
|---------------------------|------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| See comments              | West Nile Virus (West Nile-Innovator, Fort Dodge)                | 0.5-1 mL IM                                                                                                                                        | Repeat q3-4wk for 2-3 treatments                                                                                  | 3 wk                                                               | Environmental control is generally considered most important, however West Nile virus vaccine has been administered to many types of birds including Anseriformes, Ciconiiformes, Columbiformes, Coraciiformes, Passeriformes, Psittaciformes, and raptors. An antibody response has been documented inconsistently (flamingos, penguins) <sup>122,174,175,176,178</sup><br><br>Hemolytic anemia reported in lories immunized a year after first set of immunizations <sup>171</sup> |
| Canaries, housed outdoors | Pox, canary (Poximmune-C, Biomune)                               | Wing web piercing <sup>429</sup>                                                                                                                   | Wearing                                                                                                           | 6-12 mo and 4 wk before breeding and vector seasons, then annually | MLV; a "take" inflammatory reaction or scab should develop at vaccination site. May be used in the face of an epidemic in clinically normal birds <sup>8</sup>                                                                                                                                                                                                                                                                                                                       |
| Pigeons, racing           | Paramyxovirus-1 (VP, Vaccin Nobilis Lasota, Intervet)            | Apply 1-2 drops in nostrils or eyes                                                                                                                | 2-4 wk before shows/ races                                                                                        | 6-8 wk                                                             | MLV; poor immune response                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
|                           |                                                                  | Add to drinking water                                                                                                                              | —                                                                                                                 | 8 wk                                                               | 1 bottle is administered to entire flock (>100 birds), divided evenly in drinking water for 24 hr; poor immune response                                                                                                                                                                                                                                                                                                                                                              |
|                           | Paramyxovirus-1, pigeon (Inacti/vac PMV1, Maine Biological Lab)  | 0.5 mL SC <sup>429</sup>                                                                                                                           | 4 wk of age                                                                                                       | 4 wk, then annually                                                | Killed vaccine; preferred PMV-1 vaccine; vaccinate 1-2 mo before breeding season and 6-8 wk before race or show season; may be given in an outbreak <sup>429</sup>                                                                                                                                                                                                                                                                                                                   |
|                           | Paramyxovirus-1/Pox, pigeon (Columbovac, Solvay Duphar)          | 0.2 mL SC <sup>429</sup>                                                                                                                           | 4 wk of age                                                                                                       | —                                                                  | Killed vaccine; poor immunological response to pox                                                                                                                                                                                                                                                                                                                                                                                                                                   |
|                           | Pox, pigeon (Acti/vacPP, Maine Biological Lab)                   | Rub into epilated follicles on thigh or wing web with the use of a dropper or brush; stretch skin to open feather follicles <sup>423,429,762</sup> | 4 wk of age; vaccinate young birds before racing; vaccinate old birds at least 6 wk before pairing <sup>762</sup> | Annually                                                           | MLV; annual boosters may not be necessary; <sup>462</sup> booster if exposure<br><br>Administer 4 wk before mosquito season and ideally, after other vaccines are given; immunity develops 3-4 wk after administration; <sup>423</sup> vaccinated birds are infectious until vaccine lesions have healed <sup>762</sup>                                                                                                                                                              |
|                           | Salmonella typhimurium (Paratyphoid)<br><br>• (Sal Bac, Biomune) | 0.5 mL SC <sup>429</sup>                                                                                                                           | 2-3 wk before breeding, races, shows                                                                              | 3-4 wk then semi-annually                                          | Bacterin; questionable efficacy, possible reduction in fecal shedding which may contribute to control of salmonellosis; <sup>423,461</sup> complete vaccinations at least 2-3 wk before racing, showing, or egg production                                                                                                                                                                                                                                                           |

Continued

| Species     | Agent                                                                                | Dosage                                                                                                                                             | Initial                                                                                                                         | Booster                                                                                                               | Comments                                                                                                                                                                                                                          |
|-------------|--------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Psittacines | • (Bespoke, Specialist Laboratories)                                                 | 0.25 mL IM                                                                                                                                         | —                                                                                                                               | —                                                                                                                     | Persistent loft problems; <sup>43</sup> birds are often depressed for 12-24 hr post-administration; not available in the United States                                                                                            |
|             | Herpes (Pacheco's) (Psittimmune PDV, Biomune)                                        | 0.25 mL/<100 g SC <sup>42a</sup>                                                                                                                   | Wearing                                                                                                                         | 4-8 wk, then annually                                                                                                 | Killed vaccine; complete schedule at least 4 wk prior to breeding season; vaccinate healthy birds in high risk situations such as quarantine or retail outlets <sup>40a,412</sup>                                                 |
|             |                                                                                      | 0.25 mL/>100 g SC, IM <sup>42a</sup>                                                                                                               |                                                                                                                                 |                                                                                                                       | Severe granuloma formation may occur rarely at vaccination site; controversial for use in cockatoos                                                                                                                               |
|             | Polyomavirus (Psittimmune APV, Biomune)                                              | 0.25 mL/bird (that will weigh <200 g at maturity) SC <sup>42b,412</sup>                                                                            | 35-50 days of age; chicks may be safely vaccinated as young as 10-20 days of age, degree of protection uncertain <sup>415</sup> | 2-3 wk, then annually                                                                                                 | May cause discoloration, thickening, or granuloma of skin at vaccination site (usually resolves within 8 wk)                                                                                                                      |
| Raptors     |                                                                                      | 0.5 mL/bird (that will weigh >200 g at maturity) SC <sup>42b,412</sup>                                                                             |                                                                                                                                 | Last booster should be given at least 2 wk before leaving aviary <sup>414</sup>                                       | May be indicated in the face of an outbreak; <sup>4475</sup> the only vaccine for pet and aviary birds that is officially recommended for routine use; registered with the United States Department of Agriculture <sup>484</sup> |
|             | Paramyxovirus-1 (V.P. Vaccin Nobilis Lasota, Intervet)                               | Intranasally or added to drinking water                                                                                                            | —                                                                                                                               | Booster in 3-4 wk; protects × approximately 6 mo                                                                      | Hitchner B1 and Lasota strain poultry vaccines in drinking water appear to be effective; may see mild palpebral swelling for a few days <sup>391</sup>                                                                            |
| Ratites     | Pox, pigeon (Acti/vacPP, Maine Biological Lab)                                       | Rub into epilated follicles on thigh or wing web with the use of a dropper or brush; stretch skin to open feather follicles <sup>423,426,762</sup> | 4 wk of age; vaccinate young birds before racing; vaccinate old birds at least 6 wk before pairing <sup>762</sup>               | Annually                                                                                                              | Used successfully in falcons and bustards in the Middle East <sup>762</sup>                                                                                                                                                       |
|             | Eastern equine encephalitis (Triple-E, Solvay) (EEE vaccine w/o tetanus, Fort Dodge) | 0.5-1 mL IM <sup>600</sup>                                                                                                                         | 6 wk to 3 mo of age                                                                                                             | Repeat 3-4 wk later, then booster annually or biannually before and after breeding season (March/Sept) <sup>600</sup> | Emus <sup>489</sup>                                                                                                                                                                                                               |
|             | Western equine encephalitis (Triple E, Solvay)                                       | 1 mL                                                                                                                                               | 6 wk                                                                                                                            | 3-4 wk later, then every 6-12 mo <sup>600</sup>                                                                       | Emus                                                                                                                                                                                                                              |

<sup>a</sup>Vaccinating birds during an outbreak may allow humans to theoretically serve as mechanical vectors.<sup>762</sup>  
<sup>b</sup>Choose subcutaneous injection site carefully in pigeons to avoid bleeding; cranial to thigh or lower 1/3 of neck on dorsal midline.<sup>373,389</sup>

TABLE 5-49 Blood Pressure Values Reported in Birds.

| Species                          | Direct or Indirect                                                                              | Mean Arterial Pressure (mm Hg)                                              | Systolic Arterial Pressure (mm Hg)                                                                        | Diastolic Arterial Pressure (mm Hg)                                                                             |
|----------------------------------|-------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------|
| Psittacines                      | Indirect for conscious birds <sup>456</sup>                                                     | —                                                                           | 90-180                                                                                                    | —                                                                                                               |
|                                  | Indirect in birds under isoflurane anesthesia <sup>456</sup>                                    | —                                                                           | 90-150                                                                                                    | 35.26 ± 20.5                                                                                                    |
| Hispaniolan parrots <sup>a</sup> | Direct in birds under isoflurane anesthesia using the wing <sup>10</sup>                        | 155 ± 18 (112-185)                                                          | 163 ± 18 (119-200)                                                                                        | 148 ± 18 (106-171)                                                                                              |
|                                  | Direct in birds under isoflurane anesthesia using the leg <sup>10</sup>                         | 152 ± 28 (97-190)                                                           | 159 ± 28 (113-206)                                                                                        | 144 ± 30 (83-181)                                                                                               |
|                                  | Direct in birds under inhalant anesthesia <sup>721</sup>                                        | 116.9 ± 20.5                                                                | 132.9 ± 22.1                                                                                              | 101.9 ± 22                                                                                                      |
|                                  | Indirect in birds under isoflurane anesthesia using the Doppler probe on the wing <sup>10</sup> | 140 ± 25 (104-197)                                                          | —                                                                                                         | —                                                                                                               |
| Red-tailed hawks <sup>b</sup>    | Indirect in birds under isoflurane anesthesia using the Doppler probe on the leg <sup>10</sup>  | 145 ± 28 (96-196)                                                           | —                                                                                                         | —                                                                                                               |
|                                  | Indirect in birds under sevoflurane anesthesia <sup>c</sup>                                     | 155 ± 27                                                                    | 181 ± 25                                                                                                  | —                                                                                                               |
|                                  | Indirect in conscious birds <sup>c</sup>                                                        | 190 ± 38                                                                    | 236 ± 42                                                                                                  | —                                                                                                               |
|                                  | Direct in birds under sevoflurane anesthesia                                                    | 159 ± 25 (102-216)                                                          | 178 ± 27 (124-251)                                                                                        | 143 ± 24 (78-198)                                                                                               |
| Bald eagles                      | Direct in conscious birds                                                                       | 201 ± 29 (154-262)                                                          | 238 ± 39 (161-301)                                                                                        | 180 ± 31 (142-254)                                                                                              |
|                                  | Direct in spontaneously breathing birds under general anesthesia <sup>403</sup>                 | MAP was significantly elevated with isoflurane when compared to sevoflurane | 176 ± 14.4-209.3 ± 14.4 on isoflurane over 40 min<br><br>128.8 ± 15-163 ± 13.5 on sevoflurane over 40 min | 139.2 ± 14.5-171.6 ± 14.4 on isoflurane over 40 min<br><br>129.2 ± 15.2-147.1 ± 13.8 on sevoflurane over 40 min |
|                                  | Indirect in conscious birds <sup>12</sup>                                                       | 123.5 ± 61.9                                                                | —                                                                                                         | —                                                                                                               |

| Species         | Direct or Indirect                                         | Mean Arterial Pressure (mm Hg) | Systolic Arterial Pressure (mm Hg) | Diastolic Arterial Pressure (mm Hg) |
|-----------------|------------------------------------------------------------|--------------------------------|------------------------------------|-------------------------------------|
| Pekin ducks     | Direct in birds under isoflurane anesthesia <sup>290</sup> | 119 ± 17                       | —                                  | —                                   |
| Pigeons         | Direct in birds under isoflurane anesthesia <sup>805</sup> | 82 ± 14                        | —                                  | —                                   |
| Sandhill cranes | Direct in birds under isoflurane anesthesia <sup>478</sup> | 96 ± 4                         | —                                  | —                                   |

<sup>a</sup>There was substantial disagreement between direct systolic arterial blood pressure and indirect blood pressure measurements obtained with the Doppler probe from the wing and from the leg of the Hispaniolan parrot (*Amazona ventralis*); attempts to obtain indirect blood pressure measurements with an oscillometric unit were unsuccessful.<sup>10</sup>

<sup>b</sup>Zehnder AM, Hawkins MG, Pascoe PJ, et al. Evaluation of indirect blood pressure monitoring in awake and anesthetized red-tailed hawks (*Buteo jamaicensis*): effects of cuff size, cuff placement, and monitoring equipment. *Vet Anaesth Analg* 2009;36:464-479.

<sup>c</sup>Indirect blood pressure measured using an oscillometric unit was unreliable; indirect blood pressure measurements using a Doppler probe and cuff 3 were closer to direct mean arterial pressure measured from the superficial ulnar artery.

TABLE 5-50 Guidelines for Selection of Psychotherapeutic Agents for Birds. [79,283,404,412,508,589,646,731,732,739](#)

1. Perform a **complete medical and behavioral workup**:
  - Obtain a detailed medical and behavioral history.
  - Perform careful physical examination, looking for evidence of feather dysplasia or skin abnormalities.
  - Collect a minimum database that includes Psittacine Beak and Feather Disease testing, as well as skin/feather follicle biopsy when indicated.
2. Once a medical problem has been ruled out or treated, assuming the problem does not abate, form a **behavioral diagnosis**.
  - It is not enough to determine the bird is feather picking; identify “why” the bird is feather picking; use of “Antecedent, Behavior, and Consequence” data can be particularly helpful.
  - Many behavioral problems are multi-factorial in origin.
3. Formulate a **treatment plan** that incorporates:
  - Environmental modification
    - Improve the nutritional plane and basic husbandry.
    - Provide environmental enrichment where appropriate.
  - Behavioral modification techniques:
    - Focus on what you want the bird to do and reward the bird for that and/or engage in stimulating behavior that will accomplish that goal; do not punish or deprive the bird; offer behavioral alternatives or “occupational therapy” through foraging opportunities, chew and puzzle toys, and training of basic skills.



- Behavioral pharmacotherapy can be a useful component of treatment.
  - Whenever possible, consult with a behaviorist, preferably a member of the American College of Veterinary Behaviorists.
- 4. Behavioral pharmacotherapy, general principles:**
- These drugs may help the bird be more open to change, thereby reducing stress and increasing the chances of success.
  - Most behavioral drugs act by exerting effects on neurotransmitters (NT) in the central nervous system (CNS).
    - Serotonin (5-HT) affects mood, sleep patterns, and appetite; also plays a role in the suppression of impulses; low levels or an imbalance between serotonin and other hormones may be associated with maladaptive behaviors.
    - Norepinephrine (NE) plays an important role in attentiveness, sleeping, dreaming, and learning.
    - *Gamma-aminobutyric acid (GABA)* is a major inhibitory NT.
  - Behavioral drugs are classified based on their first clinical use in humans or on their structure and effects (tricyclics, selective serotonin reuptake inhibitors); major groups include anxiolytics, antipsychotics, and antidepressants, but their use may be more generalized outside of these broad areas.
  - A number of factors must be considered when selecting a psychotropic agent: the proposed mechanism of action, indications and contraindications, common side effects and the potential for other adverse effects, drug cost, and ease of administration; also consider the bird species, its age and underlying health, as well as reproductive status; see below or consult a veterinary behavior text or a general formulary for more detailed information.
- 
- Drugs commonly selected for:
    - Conditions of *fear, phobia, or anxiety* include benzodiazepines and buspirone; antidepressants may also be used for generalized anxiety and separation anxiety.
    - *Obsessive-compulsive disorders* such as stereotypical behaviors<sup>a</sup> include TCAs and SSRIs.
    - Stereotypy that involves *self-injurious behavior* include opioid antagonists (i.e., naltrexone), SSRIs, TCAs, and, in select cases, haloperidol.
    - Their *antipruritic effects* include the TCAs; doxepin, followed by amitriptyline, have the most potent antihistaminic activity.<sup>b</sup>
    - *Aggression*, both hierarchical and anxiety-induced, are the SSRIs.
  - Ancillary treatments may include NSAIDs (Table 5-6), opioid analgesics (Table 5-5), hormonal agents (Table 5-7), and/or essential fatty acid supplements when indicated.
- 5. How much to give, how often, and for how long?**
- Many of the doses in Table 5-10 are based on anecdotal experience or case reports; the few empirical studies referenced use small sample sizes.
  - Warn your client that, in many instances, dosing may be by trial and error; for instance, after giving an antidepressant for 4-8 weeks, it may be necessary to adjust the dose, or in some instances to change drugs.
  - Combination therapy can sometimes enhance drug effectiveness:

- Benzodiazepines (BZD) may be combined with antidepressants, but reduce the BZD dose to minimize the risk of CNS depression; this combination may be particularly helpful when psychotherapy is first started since it takes weeks for antidepressants to exert an effect.
- Unless both dosages are decreased, avoid combining drugs that both increase serotonin levels since there is the risk of causing serotonin syndrome.<sup>6</sup>
- Administer antidepressants for a minimum of 6-8 weeks.
- Monitor blood work regularly.
- When and if a beneficial result is achieved, it may be prudent to continue treatment for at least 2-6 months.
- The process of weaning a bird off of medication may also require trial and error; one technique is to reduce the effective dose by 25% every 3 weeks; if signs relapse, return to the lowest effective dose; taper drug dosages over a minimum of 3 weeks.

## 6. Client education

- Determine beforehand how you will document treatment response; identify target signs that can be monitored by the owner with respect to intensity, duration, and frequency.
- Prepare clients for the possibility of trial and error dosing, possible side effects, the duration of treatment that may be necessary, and the length of time before onset of desired effects.
- Extra-label drug use.

*Continued*

| Characteristics                   | Anxiolytics                                                                                                             |                                          | Antipsychotics                                                                                         | Antidepressants                                                                           |                                                                                                                   |
|-----------------------------------|-------------------------------------------------------------------------------------------------------------------------|------------------------------------------|--------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------|
|                                   | Benzodiazepines                                                                                                         | Buspirone                                |                                                                                                        | Tricyclic Compounds (TCAs)                                                                | Selective Serotonin Reuptake Inhibitors (SSRIs)                                                                   |
| Range of effects                  | Mild sedation, <sup>4</sup> to anxiolysis, to hypnosis as dose increases                                                | Calming                                  | Reduce motor activity                                                                                  | A variety including potent antihistaminic activity and some sedation                      | A variety of actions including a mood-stabilizing effect                                                          |
| Specific examples                 | Diazepam<br>Lorazepam<br>Midazolam<br>High potency: Alprazolam<br>Clonazepam                                            | —                                        | Haloperidol                                                                                            | Amitriptyline<br>Clomipramine<br>Imipramine                                               | Fluoxetine<br>Paroxetine<br>Sertraline                                                                            |
| Disadvantages                     | Can interfere with learning and affect behavioral modification                                                          | Delayed onset of action (2-4 wk)         | See below                                                                                              | Delayed onset of action (2-4 wk)                                                          | Delayed onset of action (3-6 wk)                                                                                  |
| Potential adverse effects         | Sedation, ataxia, <sup>4</sup> paradoxical excitation; rare fatal idiopathic hepatic necrosis in cats given diazepam PO | Few to mild; confusion, nausea, anorexia | Extrapyramidal signs: tremors, dystonia, dyskinesia or akathisia; transient anorexia and regurgitation | Anticholinergic signs <sup>8</sup>                                                        | Uncommon and transient; anorexia most common <sup>7</sup> and serotonin syndrome is the most serious <sup>6</sup> |
| Contraindications and precautions | Liver or renal disease; aggression; consider potential for human abuse                                                  | Severe renal or hepatic disease          | —                                                                                                      | Discontinue slowly to prevent withdrawal responses; may lower seizure threshold in humans | —                                                                                                                 |
| Taste                             | Benign, although a bitter aftertaste has been described for diazepam                                                    | —                                        | —                                                                                                      | Lingering bitter taste                                                                    | Odorless, tasteless tablets                                                                                       |

<sup>4</sup>Stereotypies are repetitive behaviors like circling or pacing, or in some instances, feather-destructive behavior.

<sup>5</sup>The antihistaminic activity of diazepam is 800-times that of diphenhydramine.

<sup>6</sup>Serotonin syndrome may cause muscle tremors, rigidity, agitation, hyperthermia, vocalization, hypertension or hypotension, tachycardia, seizures, coma, and death.

<sup>7</sup>Mild sedative effects create a risk of bird falling from perch; tolerance to sedation may develop over time.

<sup>8</sup>A variety of anticholinergic signs have been reported in mammals including dry mouth, fatigue, variable degrees of sedation, constipation, tremor, hypotension, arrhythmias, weight gain, mydriasis, and vomiting; sedation and regurgitation reported most commonly in birds.<sup>10,9</sup>

<sup>10</sup>Other possible adverse effects with SSRIs include diarrhea, increased agitation, irritability, insomnia, and, in rare instances, vomiting.

## References

1. Aarons J. First aid and wound management in the ostrich. *Proc Annu Conf Assoc Avian Vet*; 1995:201–208.
2. Aarons JE. Adverse effects of high environmental temperature on ostrich chicks. *Proc Annu Conf Assoc Avian Vet*; 1996:153–158.
3. Aarons JE. Assessing the down bird. *Proc Annu Conf Assoc Avian Vet*; 1997:175–179.
4. Abbas RZ, Iqbal Z, Khan MN, et al. Prophylactic efficacy of diclazuril in broilers experimentally infected with three field isolates of *Eimeria tenella*. *Intl J Ag Biol*. 2009;11:606–610.
5. Abernathy DR, Arnold GJ, Azarnoff DL, et al. *Mosby's Drug Consult*. St. Louis: Mosby, 2003.
6. Abou-Madi N. Avian anesthesia. *Vet Clin North Am Exotic Anim Pract*. 2001;4:147–167.
7. Abou-Madi N, Garner M, Kollias GV, et al. The use of Oxyglobin® in birds. preliminary pharmacokinetics and effects on selected blood parameters and tissues. *Proc Annu Conf Am Assoc Zoo Vet, Am Assoc Wildl Vet, Assoc Rept Amph Vet, Nat Assoc Zoo Wildl Vet*; 2001:77–79.
8. Abrams GA, Paul-Murphy J, Murphy CJ. Conjunctivitis in birds. *Vet Clin North Am Exotic Anim Pract*. 2002;5:287–309.
9. Abu-Basha EA, Idkaidek NM, Al-Shunnaq AF. Pharmacokinetics of tilmicosin (Provital powder and Pulmotil liquid AC) oral formulations in chickens. *Vet Res Com*. 2007;31:477–485.
10. Acierno MJ, da Cunha A, Smith J, et al. Agreement between direct and indirect blood pressure measurements obtained from anesthetized Hispaniolan Amazon parrots. *J Am Vet Med Assoc*. 2008;233:1587–1590.
11. Aguilar RF, Redig PT. Diagnosis and treatment of avian aspergillosis.

- Bonagura JD, ed. Kirk's Current Veterinary Therapy XII. Small Animal Practice. Philadelphia: WB Saunders Co; 1995:1294–1299.
12. Aguilar RF, Smith VE, Ogburn P, et al. Arrhythmias associated with isoflurane anesthesia in bald eagles (*Haliaeetus leucocephalus*). *J Zoo Wildl Med*. 1995;26:508–516.
13. Aiello SE, Mays A. The Merck Veterinary Manual, 8th ed, Whitehouse Station, NJ: Merck and Co, 1998.
14. Ajadi RA, Kasali OB, Makinde AF, et al. Effects of midazolam on ketamine-xylazine anesthesia in guinea fowl (*Numida meleagris galeata*). *J Avian Med Surg*. 2009;23:199–204.
15. Alderton D. *A Birdkeeper's Guide to Pet Birds*. Morris Plains, NJ: Tetra Press; 1987.
16. Allen DG, Pringle JK, Smith DA, et al. Handbook of Veterinary Drugs. 2nd ed. Philadelphia: JB Lippincott Co; 1998:749–842.
17. Allen J. Avian clinical chemistries. In: Jacobson ER, Kollias GV, Jr. *Exotic Animals*. New York: Churchill Livingstone; 1988:143–157.
18. Allen JL, Oosterhuis JE. Effect of tolazoline on xylazine-ketamine-induced anesthesia in turkey vultures. *J Am Vet Med Assoc*. 1986;189:1011–1012.
19. Al-Sobayil FA, Ahmed AF, Al-Wabel NA, et al. The use of xylazine, ketamine, and isoflurane for induction and maintenance of anesthesia in ostriches (*Struthio camelus*). *J Avian Med Surg*. 2009;23:101–107.
20. Alvarez Maldonado MVZ. Reporte preliminar. digitalizacion en pollos de engorda como metodo preventivo en el sindrome ascitico. Proc 35<sup>th</sup> Western Poult Dis Conf; 1986:4–6.
21. Amelotti I, Catala SS, Gorla DE. Response of *Triatoma infestans* to pour-on cypermethrin applied to chickens under laboratory conditions. *Mem Inst Oswaldo Cruz*. 2009;104:481–485.



22. American Veterinary Medical Association Panel on Euthanasia. Report of the AVMA Panel on Euthanasia. *J Am Vet Med Assoc*. 2001;218:669–696.
23. American Veterinary Medical Association Web site. AVMA Guidelines on Euthanasia. Available at <http://icwdm.org/PDF's/AVMA2007report.pdf>, Jun 2007. Accessed
24. Anadón A, Bringas P, Martinez-Larrañaga MR, et al. Bioavailability, pharmacokinetics and residues of chloramphenicol in the chicken. *J Vet Pharmacol Therap*. 1994;17:52–58.
25. Anadón A, Martinez-Larrañaga MR, Diaz MJ, et al. Pharmacokinetics and residues of enrofloxacin in chickens. *Am J Vet Res*. 1995;56:501–506.
26. Anadón A, Martínez-Larrañaga MR, Díaz MJ, et al. Pharmacokinetic characteristics and tissue residues for marbofloxacin and its metabolite N-desmethyl-marbofloxacin in broiler chickens. *Am J Vet Res*. 2002;63:927–933.
27. Anadón A, Martinez-Larrañaga MR, Velez C, et al. Pharmacokinetics and residues of enrofloxacin in chickens. *Am J Vet Res*. 1992;53:2084–2089.
28. Anderson NL, Johnson CK, Fender S, et al. Clinical signs and histopathologic findings associated with a newly recognized protozoal disease (*Trichomonas gallinae*) in free-ranging house finches (*Carpodacus mexicanus*). *J Zoo Wildl Med*. 2010;41:249–254.
29. Antinoff N. Improving oncologic diagnostics and therapeutics. *Proc Annu Conf Assoc Avian Vet*; 2001:369–381.
30. Antinoff N. Personal communication; 2004.
31. Archawaranon M. Hematological investigations of captive Hill Mynah *Gracula religiosa* in Thailand. *Int J Poult Sci*. 2005;4:679–682.
32. Ashworth CD, Nelson DR. Antimicrobial potentiation of irrigation solutions containing tris-[hydroxymethyl] aminomethane-EDTA. *J Am Vet Med Assoc*. 1990;197:1513–1514.

33. Assis RC, Luns FD, Beletti ME, et al. Histomorphometry and macroscopic intestinal lesions in broilers infected with *Eimeria acervulina*. *Vet Parasitol*. 2010;168:185–189.
34. Atalan G, Uzun M, Demirkan I, et al. Effect of medetomidine-butorphanol-ketamine anaesthesia and atipamezole on heart and respiratory rate and cloacal temperature of domestic pigeons. *J Vet Med A Physiol Pathol Clin Med*. 2002;49:281–285.
35. Austic RE, Scott ML. Nutritional diseases. In: Calnek BW, ed. *Diseases of Poultry*. 10th ed. Ames: Iowa State University Press; 1997:47–73.
36. Axelson RD. *Caring for Your Pet Bird*. Toronto: Canaviax Publ Ltd; 1981.
37. Axelson RD. Avian dermatology. Hoefer HL, ed. *Practical Avian Medicine. The Compendium Collection*. Trenton, NJ: Veterinary Learning Systems Co; 1997:186–195.
38. Baert K, de Backer P. Disposition of sodium salicylate, flunixin, and meloxicam after intravenous administration in broiler chickens. *J Vet Pharmacol Therap*. 2002;25:449–453.
39. Baert K, de Backer P. Comparative pharmacokinetics of three non-steroidal anti-inflammatory drugs in five bird species. *Comp Biochem Physiol C Toxicol Pharmacol*. 2003;134:25–33.
40. Baert K, Nackaerts J, de Backer P. Disposition of sodium salicylate, flunixin, and meloxicam after intravenous administration in ostriches (*Struthio camelus*). *J Avian Med Surg*. 2002;16:123–128.
41. Baert L, Van Poucke S, Vermeersch H, et al. Pharmacokinetics and anthelmintic efficacy of febantel in the racing pigeon (*Columba livia*). *J Vet Pharmacol Therap*. 1993;16:223–231.
42. Bailey J, Heard D, Schumacher J, et al. Midazolam, butorphanol, ketamine, and the clinically effective dose of isoflurane anesthesia in ostriches (*Struthio camelus*). 25th Annu Meet Am Coll Vet Anesthesiol; 2000:38.

43. Bailey TA, Apo MM. Pharmaceuticals commonly used in avian medicine. In: Samour JH, ed. *Avian Medicine*. 2nd ed. Edinburgh: Mosby Elsevier; 2008:485–509.
44. Bailey TA, Sheen RS, Samour JH, et al. Pharmacokinetics of enrofloxacin after intravenous, intramuscular and oral administration to houbara bustards (*Chlamydotis undulata macqueenii*). *J Vet Pharmacol Therap*. 1997;20(Suppl 1):204–205.
45. Baillie JW. Alternative therapy ideas for feather picking. *Proc Annu Conf Assoc Avian Vet*; 2001:191–196.
46. Battison AL, Buckzowski S, Archer FJ. Plasma bile acid concentration in the cockatiel. *Can Vet J*. 1996;37:233–234.
47. Bauck L. *A Practitioner's Guide to Avian Medicine*. Lakewood, CO: American Animal Hospital Association; 1993.
48. Bauck L. Nutritional problems in pet birds. *Semin Avian Exotic Pet Med*. 1995;4:3–8.
49. Bauck L, Brash M. Survey of diseases of the Lady Gouldian finch. *Proc Annu Conf Assoc Avian Vet*; 1999:204–212.
50. Bauck L, Hoefer HL. Avian antimicrobial therapy. *Semin Avian Exotic Pet Med*. 1993;2:17–22.
51. Bauck L, LaBonde J. Toxic diseases. In: Altman RB, Clubb SL, Dorrestein GM, et al. *Avian Medicine and Surgery*. Philadelphia: WB Saunders Co; 1997:604–613.
52. Bauck L, Hillyer E, Hoefer H. Rhinitis. case reports. *Proc Annu Conf Assoc Avian Vet*; 1992:134–139.
53. Bechert U, Christensen JM, Poppenga R, et al. Pharmacokinetics of orally administered terbinafine in African penguins (*Spheniscus demersus*) for potential treatment of aspergillosis. *J Zoo Wild Med*. 2010;41:263–274.

54. Bechert U, Christensen JM, Poppenga R, et al. Pharmacokinetics of terbinafine after single oral dose administration in red-tailed hawks (*Buteo jamaicensis*). *J Avian Med Surg*. 2010;24:122–230.
55. Beernaert LA, Baert K, Marin P, et al. Designing voriconazole treatment for racing pigeons. balancing between hepatic enzyme auto induction and toxicity. *Med Mycol*. 2009;47:276–285.
56. Beernaert LA, Pasmans F, Baert K, et al. Designing a treatment protocol with voriconazole to eliminate *Aspergillus fumigatus* from experimentally inoculated pigeons. *Vet Microbiol*. 2009;139:393–397.
57. Beernaert LA, Pasmans F, Van Waeyenberghe, et al. Avian *Asperigillus fumigatus* strain resistant to both itraconazole and voriconazole. *Antimicrob Agents Chemother*. 2009;53:2199–2201.
58. Belant JL, Seamans TW. Comparison of three formulations of alpha-chloralose for immobilization of Canada geese. *J Wildl Dis*. 1997;33:606–610.
59. Bennett RA. Common avian emergencies. Proc 5<sup>th</sup> Annu Internat Vet Emer Critical Care Symp; 1996:698–703.
60. Bennett RA. Medical and surgical management of avian reproductive disorders. Proc Mid-Atlantic States Assoc Avian Vet Conf; 1997:40–44.
61. Bernard JB, Allen ME. Feeding captive piscivorous animals. nutritional aspects of fish as food. Nutritional Advisory Group Handbook; 1997:1–11.
62. Best R. Breeding problems. In: Beynon PH, Forbes NA, Lawton MPC. *BSAVA Manual of Raptors, Pigeons and Waterfowl*. Ames: Iowa State University Press; 1996:202–215.
63. Beynon PH, Forbes NA, Harcourt-Brown NH. *Manual of Raptors, Pigeons and Waterfowl*. Ames: Iowa State University Press; 1996.
64. Beynon PH, Forbes NA, Lawton MPC. *Manual of Psittacine Birds*. Ames: Iowa State University Press; 1996.

65. Bicknese EJ. Review of avian sarcocystis. *Proc Annu Conf Assoc Avian Vet*; 1993:52–58.
66. Bird JE, Walser MM, Duke GE. Toxicity of gentamicin in red-tailed hawks (*Buteo jamaicensis*). *Am J Vet Res*. 1983;44:1289–1293.
67. Bird JE, Miller KW, Larson AA, et al. Pharmacokinetics of gentamicin in birds of prey. *Am J Vet Res*. 1983;44:1245–1247.
68. Bishop CR, Rorabaugh E. Evaluation of the safety and efficacy of selamectin in budgerigars with *Knemidokoptes* infection. *Proc Annu Conf Assoc Avian Vet*; 2010:79–84.
69. Bishop CR, McCoy B, Peter B. Selamectin tolerance in *Taeniopygia guttata* with *Sternostoma tracheacolum*. *Proc Annu Conf Assoc Avian Vet*; 2007:251–254.
70. Bishop Y, ed. *The Veterinary Formulary*, 5th ed, London: Pharmaceutical Press, 2001.
71. Black PA, Cox SK, Macek M, et al. Pharmacokinetics of tramadol hydrochloride and its metabolite O-desmethyiltramadol in peafowl (*Pavo cristatus*). *J Zoo Wildl Med*. 2010;41:671–676.
72. Black WD. A study of the pharmacodynamics of oxytetracycline in the chicken. *Poult Sci*. 1977;56:1430–1434.
73. Bloomfield RB, Brooks D, Vulliet R. The pharmacokinetics of a single intramuscular dose of amikacin in red-tailed hawks (*Buteo jamaicensis*). *J Zoo Wildl Med*. 1997;28:55–61.
74. Bonar CJ, Lewandowski AH. Use of a liposomal formulation of amphotericin B for treating wound aspergillosis in a goliath heron (*Ardea goliath*). *J Avian Med Surg*. 2004;18:162–166.
75. Bonar CJ, Lewandowski AH, Schaul J. Suspected fenbendazole toxicosis in 2 vulture species (*Gyps africanus*, *Torgos tracheliotus*) and marabou storks (*Leptoptilos crumeniferus*). *J Avian Med Surg*. 2003;17:16–19.

76. Bond MW. IME-Medication for vomiting psittacines. *J Assoc Avian Vet*. 1993;7:102.
77. Booth NH. Toxicology of drug and chemical residues. In: Booth NH, McDonald LE. *Veterinary Pharmacology and Therapeutics*. 6th ed. Ames: Iowa State University Press; 1988:1167–1179.
78. Boothe DM. Drugs affecting the respiratory system. *Vet Clin North Am Exotic Anim Pract*. 2000;3:371–394.
79. Boothe DM. Drugs that modify animal behavior. In: Boothe DM, ed. *Small Animal Clinical Pharmacology and Therapeutics*. Philadelphia: WB Saunders; 2001:457–472.
80. Bossche HV, Engelen M, Rochette F. Antifungal agents of use in animal health—chemical, biochemical and pharmacological aspects. *J Vet Pharmacol Therap*. 2003;26:5–29.
81. Bowles HL. Diagnosis and management of female avian reproductive diseases. *Proc Annu Conf Assoc Avian Vet*; 2001:349–357.
82. Bowles HL. Management with potassium bromide of seizures of undetermined origin in an umbrella cockatoo. *Exotic DVM*. 2003;4.5:7–8.
83. Bowles H, Lichtenberger M, Lennox A. Emergency and critical care of pet birds. *Vet Clin North Am Exotic Anim Pract*. 2007;10:345–394.
84. Bowman MR, Paré JA, Ziegler LE, et al. Effects of metoclopramide on the gastrointestinal tract motility of Hispaniolan parrots (*Amazona ventralis*). *Proc Annu Conf Am Assoc Zoo Vet*; 2002:117–118.
85. Bowman MR, Waldoch J, Pittman JM, et al. Enrofloxacin plasma concentrations in sandhill cranes (*Grus canadensis*) after administration in drinking water. a preliminary study. *Proc Annu Conf Am Assoc Zoo Vet*; 2002:389–390.
86. Braun EJ. Comparative renal function in reptiles, birds, and mammals. *Semin Avian Exotic Pet Med*. 1998;7:62–71.

87. Breadner S. Chronic Nocardia infection in a hyacinth macaw. *Proc Annu Conf Assoc Avian Vet*; 1994:283–285.
88. Brenner DJ, Larsen RS, Dickinson PJ, et al. Development of an avian brachial plexus nerve block technique for perioperative analgesia in mallard ducks (*Anas platyrhynchos*). *J Avian Med Surg*. 2010;24:24–34.
89. Brooks DE. Avian cataracts. *Semin Avian Exotic Pet Med*. 1997;6:131–137.
90. Brown CS. Wild bird rehabilitation for the practicing veterinarian. *Proc Annu Conf Assoc Avian Vet*; 2003:207–219.
91. Brown MJ, Cromie RL. Weight loss and enteritis. In: Beynon PH, Forbes NA, Harcourt-Brown NH. *Manual of Raptors, Pigeons and Waterfowl*. Ames: Iowa State University Press; 1996:322–329.
92. Bruch J von, Aufinger P, Jakoby JR. Untersuchungen zur pharmakokinetik und wirkung von intramuskulär, oral und über das trinkwasser verabreichtem sulfadimethoxine an gesunden und kokzidien-infizierten, adulten tauben (*Columba livia* Gmel., 1789, var. dom.). (Pharmacokinetics and efficacy of sulfadimethoxine in healthy and coccidia-infected adult pigeons). *Vet Bull*. 1986;56:7830.
93. Bunting EM, Abou Madi N, Cox S, et al. Evaluation of oral itraconazole administration in captive Humboldt penquins (*Spheniscus humboldti*). *J Zoo Wildl Med*. 2009;40:508–518.
94. Burch DGS, Harding C, Alvarez R, et al. Treatment of a field case of avian intestinal spirochaetosis caused by *Brachyspira pilosicoli* with tiamulin. *Avian Path*. 2006;35:211–216.
95. Burhenne J, Haefeli WE, Hess M, et al. Pharmacokinetics, tissue concentrations, and safety of the antifungal agent voriconazole in chickens. *J Avian Med Surg*. 2008;22:199–207.
96. Burke TJ. Antibiotic therapy in pet birds and reptiles. Weber AJ, Grey S, Townsend K, et al. *Veterinary Pharmaceuticals and Biologicals*, 5th ed, Lenexa, KS: Veterinary Medicine Publ, 1986.

97. Burns RB, Birrenkott GP. Half-life of dexamethasone and its effect on plasma corticosterone in raptors. *Proc Am Assoc Zoo Vet*; 1988:12–13.
98. Bush M, Locke D, Neal LA, et al. Gentamicin tissue concentration in various avian species following recommended dosage therapy. *Am J Vet Res*. 1981;42:2114–2116.
99. Bush M, Locke D, Neal LA, et al. Pharmacokinetics of cephalothin and cephalixin in selected avian species. *Am J Vet Res*. 1981;42:1014–1017.
100. Bush M, Neal LA, Custer RS. Preliminary pharmacokinetic studies of selected antibiotics in birds. *Proc Annu Conf Assoc Avian Vet*; 1979:45–47.
101. Butcher GD. Management of galliformes. In: Harrison GJ, Lightfoot TL, eds. *Clinical Avian Medicine*, Vol II. Palm Beach: Spix Publishing; 2006:865.
102. Byrne RF, Davis C, Lister SA, et al. Prescribing for birds. In: Bishop Y, ed. *The Veterinary Formulary*. 5th ed. London: Pharmaceutical Press; 2001:43–56.
103. Calle PP, Stewart CA. Hematologic and serum chemistry values of captive hyacinth macaws (*Anodorhynchus hyacinthinus*). *J Zoo Anim Med*. 1987;18:98–99.
104. Cambre RC, Kenny D. Vaccination of zoo birds against avian botulism with mink botulism vaccine. *Proc Annu Conf Am Assoc Zoo Vet*; 1993:383–385.
105. Campbell TW. *Biochemical evaluation of blood for the detection of hepatic disease in birds*. PhD Dissertation, Kansas State University, Manhattan, KS; 1987.
106. Campbell TW. Hematology of psittacines. Weiss DJ, Wardrop KJ. Schalm's *Veterinary Hematology*. 6<sup>th</sup> ed. Ames: Blackwell Publishing; 2010:971.
107. Campbell TW, Smith SA, Zimmerman KL. Hematology of waterfowl and raptors. Weiss DJ, Wardrop KJ. Schalm's *Veterinary Hematology*. 6<sup>th</sup> ed. Ames: Blackwell Publishing; 2010:978–979.
108. Canny CJ, Ward DA, Patton S, et al. Microsporidian keratoconjunctivitis in a double yellow-headed Amazon parrot (*Amazona ochrocephala oratrix*). *J Avian*



*Med Surg.* 1999;13:279–286.

109. Cardozo LB, Almeida RM, Fiuza LC, et al. Brachial plexus blockade in chickens with 0.75% ropivacaine. *Vet Anaesth Analg.* 2009;36:396–400.
110. Carpenter JW. Cranes (Order Gruiformes). In: Fowler ME, ed. *Zoo and Wild Animal Medicine*. 2nd ed. Philadelphia: WB Saunders Co; 1986:315–326.
111. Carpenter JW. Infectious and parasitic diseases of cranes. Fowler ME, ed. *Zoo and Wild Animal Medicine. Current Therapy 3*. Philadelphia: WB Saunders Co; 1993:229–237.
112. Carpenter JW. Gruiformes (cranes, limpkins, rails, gallinules, coots, bustards). In: Fowler ME, Miller RE. *Zoo and Wild Animal Medicine*. 5th ed. St. Louis: WB Saunders Co; 2003:171–180.
113. Carpenter JW. Personal observation; 2011.
114. Carpenter JW, Novilla MN, Hatfield JS. The safety and physiological effects of the anticoccidial drugs monensin and clazuril in sandhill cranes (*Grus canadensis*). *J Zoo Wildl Med.* 1992;23:214–221.
115. Carpenter JW, Novilla MN, Hatfield JS. Efficacy of selected coccidiostats in sandhill cranes (*Grus canadensis*) following challenge. *J Zoo Wildl Med.* 2005;36:391–400.
116. Carpenter JW, Hunter RP, Olsen JH, et al. Pharmacokinetics of marbofloxacin in blue and gold macaws (*Ara ararauna*). *Am J Vet Res.* 2006;67:947–950.
117. Carpenter JW, Olsen JH, Randle-Port M, et al. Pharmacokinetics of azithromycin in the blue and gold macaw (*Ara ararauna*) after intravenous and oral administration. *J Zoo Wildl Med.* 2005;36:606–609.
118. Carpenter JW, Tully T, Jr., Gehring R, et al. Pharmacokinetics of piperacillin/tazobactam in the Hispaniolan Amazon parrot (*Amazona ventralis*). *Proc Annu Conf Assoc of Avian Vet*; 2008:11.

119. Carpenter NA. Anseriform and galliform therapeutics. *Vet Clin North Am Exotic Anim Pract.* 2000;3:1–17.
120. Carter RT, Murphy CJ, Stuhr CM, et al. Bilateral phacoemulsification and intraocular lens implantation in a great horned owl. *J Am Vet Med Assoc.* 2007;230:559–561.
121. Chaleva EI, Vasileva IV, Savova MD. Absorption of lincomycin through the respiratory pathways and its influence on alveolar macrophages after aerosol administration to chickens. *Res Vet Sci.* 1994;57:245–247.
122. Chang GJ, Davis BS, Stringfield C, et al. Prospective immunization of the endangered California condors (*Gymnogyps californianus*) protects this species from lethal West Nile virus infection. *Vacc.* 2007;25:2325–2330.
123. Chapman HD, Matsler PL, Chapman ME. Control of coccidiosis in turkeys with diclazuril and monensin. effects upon performance and development of immunity to *Eimeria* species. *Avian Dis.* 2004;48:631–634.
124. Chitty J. A novel disinfectant in psittacine respiratory disease. *Proc Annu Conf Assoc Avian Vet;* 2002:25–27.
125. Chitty J. Birds of prey. In: Meredith A, Redrobe S. *BSAVA Manual of Exotic Pets.* Gloucester, GB: British Small Animal Veterinary Association; 2002:179–192.
126. Chitty J, Lierz M. Formulary. In: Chitty J, Lierz M. *BSAVA Manual of Raptors, Pigeons and Passerine Birds.* Gloucester: British Small Animal Veterinary Association; 2008:384–390.
127. Christensen J, Fosse RT, Halvorsen OJ, et al. Comparison of various anesthetic regimens in the domestic fowl. *Am J Vet Res.* 1987;48:1649–1657.
128. Chung HS, Jung WC, Kim DH, et al. Ceftiofur distribution in plasma and tissues following subcutaneously administration in ducks. *J Vet Med Sci.* 2007;69:1081–1085.
129. Clark CH, Thomas JE, Milton JL, et al. Plasma concentrations of

chloramphenicol in birds. *Am J Vet Res.* 1982;43:1949.

130. Clarke CR, Kocan AA, Webb AI, et al. Intravenous pharmacokinetics of penicillin G and antipyrine in ostriches and emus. *J Zoo Wildl Med.* 2001;32:74–77.

131. Cline DR, Greenwood RJ. Effects of certain anaesthetic agents on mallard ducks. *J Am Vet Med Assoc.* 1972;161:624–633.

132. Clippinger TL. Diseases of the lower respiratory tract of companion birds. *Semin Avian Exotic Pet Med.* 1997;6:201–208.

133. Clubb SL. Therapeutics. In: Harrison GJ, Harrison LR. *Clinical Avian Medicine and Surgery*. Philadelphia: WB Saunders Co; 1986:327–355.

134. Clubb SL. Birds. In: Johnston DE, ed. *The Bristol Veterinary Handbook of Antimicrobial Therapy*. 2nd ed. Trenton, NJ: Veterinary Learning Systems Co; 1987:188–199.

135. Clubb SL. Round table discussion. pain management in clinical practice. *J Avian Med Surg.* 1998;12:276–278.

136. Clubb SL, Cray C, Greiner E, Latimer KS. Cryptosporidiosis in a psittacine nursery. *Proc Annu Conf Assoc Avian Vet;* 1996:177–185.

137. Clubb SL, Schubot RM, Joyner K, et al. Hematologic and serum biochemical reference intervals in juvenile eclectus parrots (*Eclectus roratus*). *J Assoc Avian Vet.* 1990;4:218–225.

138. Clubb SL, Schubot RM, Joyner K, et al. Hematologic and serum biochemical reference intervals in juvenile cockatoos. *J Assoc Avian Vet.* 1991;5:16–26.

139. Clubb SL, Schubot RM, Joyner K, et al. Hematologic and serum biochemical reference intervals in juvenile macaws (*Ara* sp. [sic.]). *J Assoc Avian Vet.* 1991;5:154–162.

140. Clyde V, Kollias G. Diet-associated gout in juvenile macaws. *Proc Annu Conf Am Assoc Zoo Vet;* 1989:90.

141. Clyde VL, Patton S. Diagnosis, treatment and control of common parasites in companion and aviary birds. *Semin Avian Exotic Pet Med*. 1996;5:75–84.
142. Clyde VL, Paul-Murphy J. Avian analgesia. Fowler ME, Miller RE. *Zoo and Wild Animal Medicine. Current Therapy 4*. Philadelphia: WB Saunders Co; 1999:309–314.
143. Cockcroft PD, Jones AC, Harris JM. Antibacterial activity of ceftiofur-impregnated polymethylmethacrylate beads following manufacture, storage and sterilisation. *Vet Rec*. 2003;152:21–22.
144. Cole GA, Paul-Murphy J, Krugner-Higby L, et al. Analgesic effects of intramuscular administration of meloxicam in Hispaniolan parrots (*Amazona ventralis*) with experimentally induced arthritis. *Am J Vet Res*. 2009;70:1471–1476.
145. Coles BH. Cage and aviary birds. In: Beynon PH, Cooper JE. *BSAVA Manual of Exotic Pets*. Worthing, UK: British Small Animal Veterinary Association; 1991:150–179.
146. Coles BH. Appendix 1. An avian formulary. *Avian Medicine and Surgery*. 2nd ed. Oxford: Blackwell Science, Osney Mead; 1997:240–278.
147. Coles BH. Prescribing for exotic birds. In: Bishop Y, ed. *The Veterinary Formulary*. 5th ed. London: Pharmaceutical Press; 2001:99–105.
148. Cook K, Riggs G. Clinical reports. gonadotropic releasing hormones agonist implants. *Proc Annu Conf Assoc Avian Vet*; 2007:309–315.
149. Cooper JE. Appendix IX. Medicines and other agents used in treatment, including emergency anaesthesia kit and avian resuscitation protocol. Cooper JE, ed. *Birds of Prey. Health and Disease*. 3rd ed. Ames: Blackwell Publishing, Iowa State Press; 2002:271–277.
150. Cornelissen H. Behavior, anatomy, feeding and medical problems of toucans in captivity. *Proc Euro Conf Avian Med Surg*; 1993:446–453.
151. Cornelissen H. IME—Treatment of common passerine conditions. *J Assoc*

*Avian Vet.* 1993;7:103.

152. Cornelissen H, Ducatelle R, Roels S. Successful treatment of a channel-billed toucan (*Ramphastos vitellinus*) with iron storage disease by chelation therapy. sequential monitoring of the iron content of the liver during the treatment period by quantitative chemical and image analyses. *J Avian Med Surg.* 1995;9:131–137.

153. Cornick JL. *Veterinary Anesthesia*. Woburn, MA: Butterworth-Heinemann; 2001:196–198.

154. Cortright KA, Wetzlich SE, Craigmill AL. Plasma pharmacokinetics of midazolam in chickens, turkeys, pheasants and bobwhite quail. *J Vet Pharmacol Ther.* 2007;30:429–436.

155. Cousquer G. Ophthalmological findings in free-living tawny owls (*Strix aluco*) examined at a wildlife veterinary hospital. *Vet Rec.* 2005;156:734–739.

156. Cross G. Antiviral therapy. *Semin Avian Exotic Pet Med.* 1995;4:96–102.

157. Crosta L, Delli Carri AP. Oral treatment with clindamycin in racing pigeons. *Proc First Conf Euro Comm Assoc Avian Vet*; 1991:293–296.

158. Csikó GY, Banhidi GY, Semjén G, et al. Metabolism and pharmacokinetics of albendazole after oral administration to chickens. *J Vet Pharmacol Therap.* 1996;19:322–325.

159. Cubas ZS. *Medicine. Family Rhamphastidae (toucans)*. Fowler ME, Cubas ZS. *Biology, Medicine, and Surgery of South American Wild Animals*. Ames: Iowa State University Press; 2001:188–199.

160. Cubas ZS. *Toucans. husbandry and medicine*. Sao Paulo, Brazil: Proc Annu Congr World Small Anim Vet Assoc; 2009. At.

<http://www.vin.com/proceedings/Proceedings.plx?CID=WSAVA2009&Category=8063&PID=53615&Print=1&O=Generic>, December 12, 2010. Accessed

161. Cubas ZS, Godoy SN. Hemochromatosis in toucans. *Exotic DVM.* 2002;4:27–28.

162. Curro TG. Evaluation of the isoflurane-sparing effects of butorphanol and flunixin in psittaciformes. *Proc Annu Conf Assoc Avian Vet*; 1994:17–19.
163. Curro TG, Brunson DB, Paul-Murphy J. Determination of the ED50 of isoflurane and evaluation of the isoflurane-sparing effect of butorphanol in cockatoos (*Cacatua spp.*). *Vet Surg*. 1994;23:429–433.
164. Cushing A, McClean M. Use of thiafentanil-medetomidine for the induction of anesthesia in emus (*Dromaius novaehollandiae*) within a wild animal park. *J Zoo Wildl Med*. 2010;41:234–241.
165. Custer RS, Bush M, Carpenter JW. Pharmacokinetics of gentamicin in blood plasma of quail, pheasants, and cranes. *Am J Vet Res*. 1979;40:892–895.
166. Cuthbert R, Parry-Jones J, Green RE, et al. NSAIDs and scavenging birds. potential impacts beyond Asia's critically endangered vultures. *Biol Lett*. 2007;3:90–93.
167. Cybulski W, Larsson P, Tjälve H, et al. Disposition of metronidazole in hens (*Gallus gallus*) and quails (*Coturnix coturnix japonica*). pharmacokinetics and whole-body autoradiography. *J Vet Pharmacol Therap*. 1996;19:352–358.
168. Dahlhausen B. Featherpicking in pet birds. *Proc Conf Mid-Atlantic States Assoc Avian Vet*; 1997:1–5.
169. Dahlhausen B, Aldred S, Colaizzi E. Resolution of clinical proventricular dilatation disease by cyclooxygenase 2 inhibition. *Proc Annu Conf Assoc Avian Vet*; 2002:9–12.
170. Dahlhausen B, Lindstrom JG, Radabaugh CS. The use of terbinafine hydrochloride in the treatment of avian fungal disease. *Proc Annu Conf Assoc Avian Vet*; 2000:35–39.
171. Danbury TC, Weeks CA, Chambers JP, et al. Self-selection of the analgesic drug carprofen by lame broiler chickens. *Vet Rec*. 2000;146:307–311.
172. Davidson M. Ocular consequences of trauma in raptors. *Semin Avian Exotic Pet Med*. 1997;6:121–130.

173. Davies RR. Passerine birds. going light. Chitty J, Lierz M. BSAVA Manual of Raptors, Pigeons and Passerine Birds. Gloucester: British Small Animal Veterinary Association; 2008:365–369.
174. Davis MR, Langan JN, Johnson YJ, et al. West Nile virus seroconversion in penguins after vaccination with a killed virus vaccine or a DNA vaccine. *J Zoo Wildl Med*. 2008;39:582–589.
175. Day TK, Roge CK. Evaluation of sedation in quail induced by use of midazolam and reversed by use of flumazenil. *J Am Vet Med Assoc*. 1996;209:969–971.
176. De Francisco N, Ruiz Troya JD, Agüera EI. Lead and lead toxicity in domestic and free living birds. *Avian Path*. 2003;32:3–13.
177. Degernes LA. Topics in emergency medicine. fluid therapy and parenteral nutrition. Proc Avian Specialty Advanced Prog Small Mam and Rept Med Surg (Annu Conf Assoc Avian Vet); 1998:55–60.
178. Degernes L, Davidson G, Flammer K, et al. Administration of total parenteral nutrition in pigeons. *Am J Vet Res*. 1994;55:660–665.
179. Degernes LA, Fisher PE, Trogdon M, et al. Gastrointestinal scintigraphy in psittacines. Proc Annu Conf Assoc Avian Vet; 1999:93–94.
180. Degernes LA, Harrison LD, Smith DW, et al. Autologous, homologous and heterologous red blood cell transfusions in conures of the genus *Aratinga*. *J Avian Med Surg*. 1999;13:10–14.
181. De Herdt P, Devriese LA, De Groote B, et al. Antibiotic treatment of *Streptococcus bovis* infections in pigeons. Proc Euro Conf Avian Med Surg; 1993:297–304.
182. Dein FJ, Monard DF, Kowalczyk DF. Pharmacokinetics of chloramphenicol in Chinese spot-billed ducks. *J Vet Pharmacol Therap*. 1980;3:161–168.
183. de Lucas JJ, Rodríguez C, Waxman S, et al. Pharmacokinetics of marbofloxacin after intravenous and intramuscular administration to ostriches. *Vet*

J. 2005;3:364–368.

184. Denver MC, Tell LA, Galey FD. Comparison of two heavy metal chelators for treatment of lead toxicosis in cockatiels. *Am J Vet Res*. 2000;61:935–940.

185. De Voe RS, Trogon M, Flammer K. Preliminary assessment of the effect of diet and L-carnitine supplementation on lipoma size and bodyweight in budgerigars (*Melopsittacus undulatus*). *J Avian Med Surg*. 2004;18:12–18.

186. Devriese L, Dutta G. Effects of erythromycin inactivating *Lactobacillus* crop flora on blood levels. *J Vet Pharmacol Therap*. 1984;7:49–53.

187. Dierenfeld ES. Vitamin E in exotics. effects, evaluation and ecology. *J Nutr*. 1994;124:2579–2581.

188. Di Somma A, Bailey T, Silvanose C, et al. The use of voriconazole for the treatment of aspergillosis in falcons (*Falco* species). *J Avian Med Surg*. 2007;21:307–316.

189. Dodwell GT. *The Complete Book of Canaries*. London: Merehurst Press; 1986.

190. Doneley B. Acute pancreatitis in parrots. *Exotic DVM*. 2003;4:13–16.

191. Doneley B. Management of captive ratites. In: Harrison GJ, Lightfoot TL, eds. *Clinical Avian Medicine*, Vol II. Palm Beach: Spix Publishing; 2006:957–989.

192. Doneley B. The use of gabapentin to treat presumed neuralgia in a little corella (*Cacatua sanguinea*). *Proc Australian Assoc Avian Vet*; 2007:169–172.

193. Doneley B. Formulary. Doneley B, ed. *Avian Medicine and Surgery in Practice. Companion and Aviary Birds*. London: Manson Publishing; 2011:285–320.

194. Doolen M. Adriamycin® chemotherapy in a blue-front Amazon with osteosarcoma. *Proc Annu Conf Assoc Avian Vet*; 1994:89–91.



195. Dorrestein GM. *Studies on pharmacokinetics of some antibacterial agents in homing pigeons (Columba livia)*. Thesis, Utrecht University; 1986.
196. Dorrestein GM. Formulation and (bio)availability problems of drug formulations in birds. *J Vet Pharmacol Therap*. 1992;15:143–150.
197. Dorrestein GM. Antimicrobial drug use in companion birds. In: Prescott JF, Baggot JD. *Antimicrobial Therapy in Veterinary Medicine*. 2nd ed. Ames: Iowa State University Press; 1993:491–506.
198. Dorrestein GM. Infectious diseases and their therapy in Passeriformes. In: *Antimicrobial Therapy in Caged Birds and Exotic Pets*. Trenton, NJ: Veterinary Learning Systems Co; 1995:11–27.
199. Dorrestein GM. Antimicrobial drug use in companion birds. In: Prescott JF, Baggot JD, Walker RD. *Antimicrobial Therapy in Veterinary Medicine*. 3rd ed. Ames: Iowa State University Press; 2000:617–636.
200. Dorrestein GM. Passerine and softbill therapeutics. *Vet Clin North Am Exotic Anim Pract*. 2000;3:35–57.
201. Dorrestein GM, Kazemi SM, Eksik N. Comparative study of Synulox® and Augmentin® after intravenous, intramuscular and oral administration in collared doves (*Streptopelia decaocto*). In: Kösters J, et al. *X. Tagung der Fachgruppe "Geflügelkrankheiten."*. Giessen, Germany: Deutschen Veterinärmedizinischen Gesellschaft e.V; 1996:42–54.
202. Dorrestein GM, van der Hage M, Kik M, et al. Syngamus trachea. an unusual infection in Vinaceous Amazons (*Amazona vinacea*). *Proc Annu Conf Assoc Avian Vet*; 2001:59–65.
203. Dorrestein GM, Van Der Horst HHA, Cremers HJWM, et al. Quill mite (*Dermoglyphus passerinus*) infestation of canaries (*Serinus canaria*). diagnosis and treatment. *Avian Pathol*. 1997;26:195–199.
204. Dorrestein GM, van Gogh H, Rinzema JD. Pharmacokinetic aspects of penicillins, aminoglycosides and chloramphenicol in birds compared to mammals. A review. *Vet Quart*. 1984;6:216–224.

205. Dorrestein GM, Van Gogh H, Rinzema JD, et al. Comparative study of ampicillin and amoxicillin after intravenous, intramuscular and oral administration in homing pigeons (*Columba livia*). *Res Vet Sci*. 1987;42:343–348.
206. Drug Facts and Comparisons. *Drug Facts and Comparisons 2003*. Philadelphia: Lippincott Williams and Wilkins; 2002.
207. Dumonceaux G, Harrison GJ. Toxins. Ritchie BW, Harrison GJ, Harrison LR. *Avian Medicine. Principles and Application*. Delray Beach, FL: Wingers Publishing; 1994:1030–1052.
208. Dyer DC, Van Alstine WG. Antibiotic aerosolization. tissue and plasma oxytetracycline concentrations in parakeets. *Avian Dis*. 1987;31:677–679.
209. Echols S, Speer B. Omega-3 fatty acid supplementation. potential uses and limitations. *Proc Annu Conf Assoc Avian Vet*; 2000:13–16.
210. Edling TM. Anaesthesia and analgesia. In: Chitty J, Harcourt-Brown N. *BSAVA Manual of Psittacine Birds*. Gloucester: British Small Animal Veterinary Association; 2005:87–96.
211. Efstathopoulos N, Giamarellos-Bourboulis E, Kanellakopoulou K, et al. Treatment of experimental osteomyelitis by methicillin resistant *Staphylococcus aureus* with bone cement system releasing grepafloxacin. *Injury*. 2008;39:1384–1390.
212. Ehrlich PR, Dobkin DS, Wheye D. *The Birder's Handbook. A Field Guide to the Natural History of North American Birds*. New York: Simon & Schuster; 1988.
213. El-Banna HA, El-Bahy MM, El-Zorba HY, et al. Anticoccidial efficacy of drinking water soluble diclazuril on experimental and field coccidiosis in broiler chickens. *J Vet Med A Physiol Pathol Clin Med*. 2005;52:287–291.
214. El-Gammal AA, Ravis WR, Krista LM, et al. Pharmacokinetics and intramuscular bioavailability of amikacin in chickens following single and multiple dosing. *J Vet Pharmacol Therap*. 1992;15:133–142.
215. El-Gendi AY, el-Banna HA, Abo Norag M, et al. Disposition kinetics of

danofloxacin and ciprofloxacin in broiler chickens. *Dtsch Tierarztl Wochenschr*; 2001;429–434.

216. El-Kholy H, Kemppainen B, Ravis W, et al. Pharmacokinetics of levamisole in broiler breeder chickens. *J Vet Pharm Therap*. 2006;29:49–53.

217. Elliston E, Perlman J. Meeting the protein requirements of adult hummingbirds in captivity. *J Wildl Rehab*. 2002;25:14–19.

218. Ensley PK, Janssen DL. A preliminary study comparing the pharmacokinetics of ampicillin given orally and intramuscularly to psittacines. Amazon parrots (*Amazona* spp.) and blue-naped parrots (*Tanygnathus lucionensis*). *J Zoo Anim Med*. 1981;12:42–47.

219. Ernst S, Goggin JM, Biller DS, et al. Comparison of iohexol and barium sulfate as gastrointestinal contrast media in mid-sized psittacine birds. *J Avian Med Surg*. 1998;12:16–20.

220. Escobar A, Thiesen R, Vitaliano SN, et al. Some cardiopulmonary effects of sevoflurane in crested caracara (*Caracara plancus*). *Vet Anaesth Analg*. 2009;36:436–441.

221. Espigol C, Artigas C, Palmada J, et al. Serum levels of doxycycline during water treatment in poultry. *J Vet Pharmacol Therap*. 1997;20:192–193.

222. Esposito JF. Respiratory medicine. *Vet Clin North Am Exotic Anim Pract*. 2000;3:395–402.

223. Ethell MT, Bennett RA, Brown MP, et al. In vitro elution of gentamicin, amikacin and ceftiofur from polymethylmethacrylate and hydroxyapatite cement. *Vet Surg*. 2000;29:375–382.

224. Eugenio CT. Amitriptyline HCl. Clinical study for treatment of feather picking. *Proc Annu Conf Assoc Avian Vet*; 2003:133–135.

225. Evans EE, Wade LL, Flammer K. Administration of doxycycline in drinking water for treatment of spiral bacterial infection in cockatiels. *J Am Vet Med Assoc*. 2008;232:389–393.

226. Evrard HC, Balthazart J. The assessment of nociceptive and non-nociceptive skin sensitivity in the Japanese quail (*Coturnix japonica*). *J Neurosci Methods*. 2002;116:135–146.
227. Farca AM, Piromalli G, Maffei F, et al. Potentiating effect of EDTA-Tris on the activity of antibiotics against resistant bacteria associated with otitis, dermatitis and cystitis. *J Small Anim Pract*. 1997;38:243–245.
228. Ferrell ST, Graham JE, Swaim SF. Avian wound healing and management. *Proc Annu Conf Assoc Avian Vet*; 2002:337–347.
229. Figueiredo JP, Cruz ML, Mendes GM, et al. Assessment of brachial plexus blockade in chickens by an axillary approach. *Vet Anaesth Analg*. 2008;35:511–518.
230. Filippich LJ, O'Donoghue PJ. *Cochlosoma* infections in finches. *Aust Vet J*. 1997;75:561–563.
231. Filippich LJ, Parker MG. Megabacteria and proventricular/ventricular disease in psittacines and passerines. *Proc Annu Conf Assoc Avian Vet*; 1994:287–293.
232. Filippich LJ, Perry RA. Drug trials against megabacteria in budgerigars (*Melopsittacus undulatus*). *Aust Vet Pract*. 1993;23:184–189.
233. Filippich LJ, Bucher AM, Charles BG. Platinum pharmacokinetics in sulphur-crested cockatoos (*Cacatua galerita*) following single-dose cisplatin infusion. *Aust Vet J*. 2000;78:406–411.
234. Filippich LJ, Gilbert CM, Charles BG. Pharmacokinetics of doxorubicin in cockatoos (*Cacatua galerita*). *Proc Annu Conf Assoc Avian Vet*; 2004:25–27.
235. Filippich LJ, Bucher AM, Charles BG, et al. Intravenous cisplatin administration in sulphur-crested cockatoos (*Cacatua galerita*). clinical and pathologic observations. *J Avian Med Surg*. 2001;15:23–30.
236. Filippich LJ, Charles BG, Sutton RH, et al. Carboplatin administration in sulphur-crested cockatoos (*Cacatua galerita*). clinical observations. *J Avian Med Surg*. 2005;19:92–97.

237. Fitzgerald G, Cooper JE. Preliminary studies on the use of propofol in the domestic pigeon (*Columba livia*). *Vet Sci*. 1990;49:334–338.
238. Flammer K. An overview of antifungal therapy in birds. *Proc Annu Conf Assoc Avian Vet*; 1993:1–4.
239. Flammer K. A review of the pharmacology of antimicrobial drugs in birds. *Proc Avian/Exotic Anim Med Symp*; 1994:65–78.
240. Flammer K. Fluconazole in psittacine birds. *Proc Annu Conf Assoc Avian Vet*; 1996:203–204.
241. Flammer K. Approach to the vomiting bird. *Proc 21st Annu Waltham®/OSU Symp*; 1997:19–21.
242. Flammer K. Common bacterial infections and antibiotic use in companion birds. *Antimicrobial Therapy in Exotics; Supplement to Comp Cont Edu Pract Vet*. 1998;20(3A):34–48.
243. Flammer K. Doxycycline-medicated seed for treatment of chlamydiosis. *Proc Annu Conf Assoc Avian Vet*; 2002:7–8.
244. Flammer K. Treatment of bacterial and mycotic diseases of the avian gastrointestinal tract. *Proc North Am Vet Conf*; 2002:851–852.
245. Flammer K. Antifungal drug update. *Proc Annu Conf Assoc of Avian Vet*; 2006:3.
246. Flammer K, Papich M. Assessment of plasma concentration and effects of injectable doxycycline in three psittacine species. *J Avian Med Surg*. 2005;19:216–224.
247. Flammer K, Whitt-Smith D. Plasma concentrations of enrofloxacin psittacine birds offered water medicated with 200 mg/L of the injectable formulation of enrofloxacin. *J Avian Med Surg*. 2002;16:286–290.
248. Flammer K, Aucoin DP, Whitt DA. Intramuscular and oral disposition of enrofloxacin in African grey parrots following single and multiple doses. *J Vet*

*Pharmacol Therap.* 1991;41:359–366.

249. Flammer K, Whitt-Smith D, Papich M. Plasma concentrations of doxycycline in selected psittacine birds when administered in water for potential treatment of *Chlamydophila psittaci* infection. *J Avian Med Surg.* 2001;15:276–282.

250. Flammer K, Aucoin DP, Whitt DA, et al. Plasma concentrations of enrofloxacin in African grey parrots treated with medicated water. *Avian Dis.* 1990;34:228–234.

251. Flammer K, Aucoin DP, Whitt DA, et al. Potential use of long-acting injectable oxytetracycline for treatment of chlamydiosis in Goffin's cockatoos. *Avian Dis.* 1990;34:1017–1022.

252. Flammer K, Cassidy DR, Landgraf WW, et al. Blood concentrations of chlortetracycline in macaws fed a medicated pelleted feed. *Avian Dis.* 1989;33:199–203.

253. Flammer K, Clark CH, Drewes LA, et al. Adverse effects of gentamicin in scarlet macaws and galahs. *Am J Vet Res.* 1990;51:404–407.

254. Flammer K, Nettifee-Osborne JA, Webb DJ, et al. Pharmacokinetics of voriconazole after oral administration of single and multiple doses in African grey parrots (*Psittacus erithacus timneh*). *Am J Vet Res.* 2008;69:114–121.

255. Flinchum GB. Potential use of policosanol in the treatment of hyperlipidemia in pet birds. *Exotic DVM.* 2003;5:51–55.

256. Fontenot DK, Terrell SP, Neiffer DL, et al. Clinical trial of a depot form of levonorgestrel in domestic turkeys. *Proc Annu Conf Assoc Avian Vet;* 2002:43.

257. Food and Drug Administration. FDA prohibits nitrofurantoin drug used in food-producing animal. <http://www.fda.gov/cvm/index/updates/nitroup.htm>, 2002.

258. Food and Drug Administration. Reminder-extra-label use of fluoroquinolones prohibited. <http://www.fda.gov/cvm/index/updates/noelufq.htm>, 2002.

259. Forbes NA. Birds of prey. In: Beynon PH, Cooper JE. *BSAVA Manual of Exotic Pets*. Ames: Iowa State University Press; 1991:212–220.
260. Forbes NA. Respiratory problems. In: Beynon PH, Forbes NA, Lawton MPC. *BSAVA Manual of Psittacine Birds*. Ames: Iowa State University Press; 1996:147–157.
261. Forbes NA. Raptors. parasitic diseases. Chitty J, Lierz M. *BSAVA Manual of Raptors, Pigeons and Passerine Birds*. Gloucester: British Small Animal Veterinary Association; 2008:202–211.
262. Forbes NA, Fox MT. Control of endemic *Caryospora*-species infestation of captive raptors. *Proc Annu Conf Assoc Avian Vet*; 2000:173–179.
263. Forbes NA, Richardson T. Husbandry and nutrition. In: Beynon PH, Forbes NA, Harcourt-Brown NH. *BSAVA Manual of Raptors, Pigeons and Waterfowl*. Ames: Iowa State University Press; 1996:289–298.
264. Ford S, Chitty J, Jones MP. Raptor medicine master class. *Proc Annu Conf Assoc Avian Vet*; 2009:143–162.
265. Forshaw JM, Cooper WT. *Parrots of the World*, 3rd ed. Melbourne: Lansdowne Editions; 1989.
266. Fowler GS, Fowler ME. Order Sphenisciformes (penguins). In: Fowler ME, Cubas ZS. *Biology, Medicine, and Surgery of South American Wild Animals*. Ames: Iowa State University Press; 2001:53–64.
267. Fowler ME. *Restraint and Handling of Wild and Domestic Animals*, 2nd ed. Ames: Iowa State University Press; 1995.
268. Fowler ME. Captive management and medicine. In: Fowler ME, Cubas ZS. *Biology, Medicine, and Surgery of South American Wild Animals*. Ames: Iowa State University Press; 2001:105–114.
269. France M. Chemotherapy treatment of lymphosarcoma in a Moluccan cockatoo. *Proc Annu Conf Assoc Avian Vet*; 1993:15–19.

270. Frazier DL. Avian toxicology. In: Olsen GH, Orosz SE. *Manual of Avian Medicine*. St. Louis: Mosby; 2000:228–263.
271. Friffin C, Snelling LR. Use of hyaluronidase in avian subcutaneous fluids. *Proc Annu Conf Assoc Avian Vet*; 1998:239–240.
272. Fudge AM. Blood testing artifacts. interpretation and prevention. *Semin Avian Exotic Pet Med*. 1994;3:2–4.
273. Fudge AM. Laboratory reference ranges for selected avian, mammalian, and reptilian species. In: Fudge AM, ed. *Laboratory Medicine: Avian and Exotic Pets*. Philadelphia: WB Saunders Co; 2000:375–400.
274. Fudge AM, Joseph V. Disorders of avian leukocytes. Fudge AM, ed. *Laboratory Medicine. Avian and Exotic Pets*. Philadelphia: WB Saunders Co; 2000:19–25.
275. Fudge AM, Reavill DR, Roskopf WJ, Jr. Diagnosis and management of avian dyspnea. a review. *Proc Annu Conf Assoc Avian Vet*; 1993:187–195.
276. Gaggermeier B, Henke J, Schatzmann U. Investigations on analgesia in domestic pigeons (*C. livia*, Gmel., 1789, var. dom.) using buprenorphine and butorphanol. *Proc Eur Assoc Avian Vet*; 2003:70–73.
277. Galvin C. Laboratory diagnostic aids in pet bird practice. *Proc Annu Conf Am Anim Hosp Assoc*; 1980:41–52.
278. Gancz A, Wellehan J, Boutette J, et al. Diabetes mellitus concurrent with hepatic haemosiderosis in two macaws (*Ara severa*, *Ara militaris*). *Avian Pathol*. 2007;36:331–336.
279. García-Montijano M, Gonzáles F, Waxman S, et al. Pharmacokinetics of marbofloaxacin after oral administration to Eurasian buzzards (*Buteo buteo*). *J Avian Med Surg*. 2003;17:185–190.
280. Garcia-Montijano M, Waxman S, de Lucas JJ, et al. The pharmacokinetic behaviour of marbofloxacin in Eurasian buzzards (*Buteo buteo*) after intraosseous administration. *Vet J*. 2006;171:551–555.



281. Garcia-Montijano M, Waxman S, de Lucas JJ, et al. *Disposition of marbofloxacin in vulture (Gyps fulvus) after intravenous administration of a single dose*. Res Vet Sci; 2010. epub
282. García-Ovando H, Chiostri E, Ugnia L, et al. HPLC residues of enrofloxacin and ciprofloxacin in eggs of laying hens. *J Vet Pharmacol Therap*. 1997;20:204.
283. Gaskins LA, Massey JG, Ziccardi MH. Effect of oral diazepam on feeding behavior and activity of Hawai'i' amakihi (*Hemignathus virens*). *Appl Anim Behav Sci*. 2008;112:384–394.
284. Gentle MJ, Hocking PM, Bernard R, et al. Evaluation of intraarticular opioid analgesia for the relief of articular pain in the domestic fowl. *Pharmacol Biochem Behav*. 1999;63:339–343.
285. Gentz EJ, Dykes NL, Kollias GV, et al. Comparison of barium and iohexol as gastrointestinal contrast media in avian radiography. *Proc Annu Conf Am Assoc Zoo Vet*; 1999:197.
286. Giddings RF. Treatment of flukes in a toucan. *J Am Vet Med Assoc*. 1988;193:1555–1556.
287. Gill JH. Avian skin diseases. *Vet Clin North Am Exotic Anim Pract*. 2001;4:486.
288. Giorgi M, Soldani G. Pharmacokinetic study of clazuril (Appertex) in eggs and plasma from laying hens after single or multiple treatments, using a new HPLC method for detection. *Br Poult Sci*. 2008;49:609–618.
289. Glatz PC, Murphy BL, Preston AP. Analgesia therapy of beak-trimmed chickens. *Aust Vet J*. 1992;69:18.
290. Goelz MF, Hahn AW, Kelley ST. Effects of halothane and isoflurane on mean arterial blood pressure, heart rate, and respiratory rate in adult Pekin ducks. *Am J Vet Res*. 1990;51:458–460.
291. Goodwin JS, Jacobson ER, Gaskin JM. Effects of Pacheco's parrot disease virus on hematologic and blood chemistry values of Quaker parrots (*Myopsitta*

monachus). *J Zoo Anim Med.* 1982;13:127–132.

292. Gould WJ. Caring for birds' skin and feathers. *Vet Med*; 1995:53–63. (Jan)

293. Graczyk T, Shaw M, Cranfield MR, et al. Hematological characteristics of avian malaria cases in African black-footed penguins. *J Parasitol.* 1994;80:302–308.

294. Graham JE, Tell LA, Kollias-Baker C, et al. Pharmacokinetics of ketoprofen in adult Japanese quail (*Coturnix japonica*). *Proc Annu Conf Assoc Avian Vet*; 2001:19–21.

295. Graham JE, Tell LA, Kollias-Baker C, et al. Preliminary investigation into the pharmacodynamics of ketoprofen in quail. *Proc Annu Conf Assoc Avian Vet*; 2002:75–76.

296. Gray P, Gou J, Shivaprasad HL, et al. Use of antiviral drugs for treatment of avian bornavirus infection. *Proc Annu Conf Assoc Avian Vet*; 2010:19.

297. Greenacre CB, Young DW, Behrend EN, et al. Validation of a novel high-sensitivity radioimmunoassay procedure for measurement of total thyroxine concentration in psittacine birds and snakes. *Am J Vet Res.* 2001;62:1750–1754.

298. Greenacre CB, Olsen J, Wilson GH, et al. The use of synthetic TSH to evaluate the thyroid gland. *Proc Annu Conf Assoc Avian Vet*; 2002:13.

299. Gregory CR. Proventricular dilatation disease. Ritchie BW, ed. *Avian Viruses. Function and Control.* Lake Worth, FL: Wingers Publishing; 1995:439–448.

300. Greth A, Gerlach H, Gerbermann H, et al. Pharmacokinetics of doxycycline after parenteral administration in the houbara bustard (*Chlamydotis undulata*). *Avian Dis.* 1993;37:31–36.

301. Griminger P. Vitamin K antagonists. *J Nutr.* 1987;117:1325–1329.

302. Grimm F, Serbest E. The therapy of osteomyelitis with clindamycin in patients suffering from fractures. München: Proc VIII Tagung über

Vogelkrankheiten; 1992:252–254.

303. Gronwall R, Brown MP, Clubb S. Pharmacokinetics of amikacin in African gray parrots. *Am J Vet Res.* 1989;50:250–252.

304. Guo FC, Suo X, Zhang GZ, et al. Efficacy of decoquinate against drug sensitive laboratory strains of *Eimeria tenella* and field isolates of *Eimeria* spp. in broiler chickens in China. *Vet Parasitol.* 2007;147:239–245.

305. Guzman DS-M, Diaz-Figueroa O, Tully T, Jr., et al. Evaluating 21-day doxycycline and azithromycin treatments for experimental *Chlamydophila psittaci* infection in cockatiels (*Nymphicus hollandicus*). *J Avian Med Surg.* 2010;24:35–45.

306. Guzman DS-M, Flammer K, Papich MG, et al. Pharmacokinetics of voriconazole after oral administration of single and multiple doses in Hispaniolan Amazon parrots (*Amazona ventralis*). *Am J Vet Res.* 2010;71:460–467.

307. Haberkorn A, et al. *The use of Bay VI 9142 (Baycox®), a new coccidiocide, in waterfowl, particularly in the goose.* Proc Conf Avian Dis; 1988.

308. Hamamoto K, Koike R, Machida Y. Bioavailability of amprolium in fasting and nonfasting chickens after intravenous and oral administration. *J Vet Pharmacol Ther.* 2000;23:9–14.

309. Hamdy AH, Saif YM, Kasson CW. Efficacy of lincomycin-spectinomycin water medication on *Mycoplasma meleagridis* air sacculitis in commercially raised turkey poults. *Avian Dis.* 1981;26:227–233.

310. Hamdy AH, Kratzer DD, Paxton LM, et al. Effect of a single injection of lincomycin, spectinomycin, and linco-spectin on early chick mortality caused by *E. coli* and *S. aureus*. *Avian Dis.* 1979;24:164–173.

311. Hamlin RL, Stalnaker PS. Basis for use of digoxin in small birds. *J Vet Pharmacol Therap.* 1987;10:354–356.

312. Haneveld-v Laarhoven MA, Dorrestein GM. IME—Sudden high mortality in canaries. *J Assoc Avian Vet.* 1990;4:82.

313. Hannon DE, Swaim SF, Milton JL, et al. Full thickness mesh skin grafts in two great horned owls. *J Zoo Wildl Med*. 1993;24:539–542.
314. Hanssen I, Grav HJ, Steen H. Vitamin C deficiency in growing willow ptarmigan (*Lagopus lagopus lagopus*). *J Nutr*. 1979;109:2260–2276.
315. Hantash TM, Abu-Basha EA. Pharmacokinetics and bioavailability of a sulfadiazine/trimethoprim combination following intravenous, intramuscular, and oral administration in ostriches (*Struthio camelus*). *Proc Annu Conf Assoc Avian Vet*; 2008:319–324.
316. Harcourt-Brown NH. Tendon repair in the pelvic limb of birds of prey. Part II. Surgical techniques. In: *Raptor Biomedicine III*. Lake Worth, FL: Zoological Education Network; 2002:217–231.
317. Harcourt-Brown N, Chitty J. Formulary. In: Harcourt-Brown N, Chitty J. *BSAVA Manual of Psittacine Birds*. Gloucester: British Small Animal Veterinary Association; 2005:303–308.
318. Hardey J, Crick H, Wernham C, et al. *Raptors. A Field Guide to Survey and Monitoring*. Edinburgh: Scottish Natural Heritage; 2006.
319. Haritova AM, Rusenova NV, Parvanov PR, et al. Integration on pharmacokinetic and pharmacodynamic indices of marbofloxacin in turkeys. *Antimicrob Agents Chemother*. 2006;50:3779–3785.
320. Harlin RW. Pigeons. *Vet Clin North Am Small Anim Pract*. 1994;24:157–173.
321. Harlin RW. Backyard poultry. *Proc Mid-Atlantic States Assoc Avian Vet Conf*; 1995:65–68.
322. Harlin RW. Pigeons. *Proc Annu Conf Assoc Avian Vet*; 1995:361–373.
323. Harlin RW. Pigeon therapeutics. *Vet Clin North Am Exotic Anim Pract*. 2000;3:19–34.
324. Harlin RW. Practical pigeon medicine. *Proc Annu Conf Assoc Avian Vet*;

2006:249–262.

325. Harper FDW. Poor performance and weight loss. In: Beynon PH, Forbes NA, Harcourt-Brown NH. *BSAVA Manual of Raptors, Pigeons and Waterfowl*. Ames: Iowa State University Press; 1996:272–278.

326. Harrenstien LA, Tell LA, Vulliet R, et al. Disposition of enrofloxacin in red-tailed hawks (*Buteo jamaicensis*) and great horned owls (*Bubo virginianus*) after a single oral, intramuscular, or intravenous dose. *J Avian Med Surg*. 2000;14:228–236.

327. Harris D. Therapeutic avian techniques. *Semin Avian Exotic Pet Med*. 1997;6:55–62.

328. Harrison GJ. What to do until a diagnosis is made. In: Harrison GJ, Harrison LR. *Clinical Avian Medicine and Surgery*. Philadelphia: WB Saunders Co; 1986:356–361.

329. Harrison GJ, Harrison LR. *Clinical Avian Medicine and Surgery*. Philadelphia: WB Saunders Co; 1986:662–663.

330. Harvey R. *Practical Incubation*. Suffolk, UK: Payn Essex Printers Ltd, Sudbury; 1990.

331. Harvey-Clark C, Gass CL. IME—Treating aspergillosis in hummingbirds. *J Assoc Avian Vet*. 1993;7:216.

332. Hawk CT, Leary SL. *Formulary for Laboratory Animals*, 2nd ed. Ames: Iowa State University Press; 1999.

333. Hawkey CM, Samour HJ. The value of clinical hematology in exotic birds. In: Jacobson ER, Kollias GV, Jr. *Exotic Animals*. New York: Churchill Livingstone; 1988:109–141.

334. Hawkins MG, Machin KL. Avian pain and analgesia. *Proc Annu Conf Assoc Avian Vet*; 2004:165–174.

335. Hawkins MG, Taylor IT, Byrne BA, et al. The pharmacokinetics and

pharmacodynamics of orbifloxacin in Japanese quail (*Coturnix coturnix japonica*). *Proc Annu Conf Assoc Avian Vet*; 2010:25.

336. Hawkins MG, Wright BD, Pascoe PJ, et al. Pharmacokinetics and anesthetic and cardiopulmonary effects of propofol in red-tailed hawks (*Buteo jamaicensis*) and great horned owls (*Bubo virginianus*). *Am J Vet Res*. 2003;64:677–683.

337. Heard D. Anesthesia and analgesia. In: Altman RB, Clubb SL, Dorrestein GM, et al. *Avian Medicine and Surgery*. Philadelphia: WB Saunders Co; 1997:807–827.

338. Heatley JJ, Gill H, Crandall L, et al. Enilconazole for treatment of raptor aspergillosis. *Proc Annu Conf Assoc Avian*; 2007:287–288.

339. Heaton JT, Brauth SE. Effects of yohimbine as a reversing agent for ketamine-xylazine anesthesia in budgerigars. *Lab Anim Sci*. 1992;42:54–56.

340. Hedberg GE, Bennett RA. Preliminary studies on the use of milbemycin oxime in galliformes. *Proc Annu Conf Assoc Avian Vet*; 1994:261–264.

341. Heidenreich M. *Birds of Prey, Medicine and Management*. Malden, MA: Blackwell Science Ltd; 1997.

342. Heinen E, DeJong A, Scheer M. Antimicrobial activity of fluoroquinolones in serum and tissues in turkeys. *J Vet Pharmacol Therap*. 1997;20(Suppl 1):196–197.

343. Helmer P. Psittacine sarcocystosis. *Proc Annu Conf Assoc Avian Vet*; 2004:602.

344. Helmick KE, Boothe DM, Jensen JM. Disposition of single-dose intravenously administered amikacin in emus. *J Zoo Wildl Med*. 1997;28:49–54.

345. Helmick KE, Boothe DM, Jensen JM. Disposition of single-dose intravenously administered enrofloxacin in emus. *J Zoo Wildl Med*. 1997;28:43–48.

346. Hess L. Possible complications associated with topical corticosteroid use in

birds. *Proc Annu Conf Assoc Avian Vet*; 2001:29–32.

347. Hess L. Corticosteroid synthesis and metabolism in birds. *Semin Avian Exotic Pet Med*. 2002;11:65–70.

348. Hines R, Kolattukuty PE, Sharkey P. Pharmacological induction of molt and gonadal involution in birds. *Proc Annu Conf Assoc Avian Vet*; 1993:127–134.

349. Hirsch DC, Knox SJ, Couzelman GM, Jr., et al. Pharmacokinetics of penicillin-G in the turkey. *Am J Vet Res*. 1978;39:1219–1221.

350. Hochleithner M. Reference values for selected psittacine species using a dry chemistry system. *J Assoc Avian Vet*. 1989;3:207–209.

351. Hocking PM, Robertson GW, Gentle MJ. Effects of non-steroidal anti-inflammatory drugs on pain-related behaviour in a model of articular pain in the domestic fowl. *Res Vet Sci*. 2005;78:69–75.

352. Hocking PM, Gentle MJ, Bernard R, et al. Evaluation of a protocol for determining the effectiveness of pretreatment with local analgesics for reducing experimentally induced articular pain in domestic fowl. *Res Vet Sci Lond*. 1997;63:263–267.

353. Hoefer H. IME—Hepatic fibrosis and colchicine therapy. *J Assoc Avian Vet*. 1991;5:193.

354. Hoefer HL. Antimicrobials in pet birds. Bonagura JD, ed. *Kirk's Current Veterinary Therapy XII. Small Animal Practice*. Philadelphia: WB Saunders Co; 1995:1278–1283.

355. Hogan HL, Joseph B, Henrickson R, et al. Efficacy and safety of ivermectin treatment for scaley leg mite infestation in parakeets. *Proc Annu Conf Am Assoc Zoo Vet*; 1984:156.

356. Holt E, Rosenthal K, Shofer FS. The phenol red thread tear test in large Psittaciformes. *Vet Ophthalmol*. 2006;9:109–113.

357. Hoogesteijn AL, Raphael BL, Calle P, et al. Oral treatment of avian lead

intoxication with meso-2,3-dimercaptosuccinic acid. *J Zoo Wildl Med*. 2003;34:82–87.

358. Hooimeijer J. Coccidiosis in lorikeets infectious for budgerigar. *Proc Annu Conf Assoc Avian Vet*; 1993:59–61.

359. Hoppes S. Common parasites in companion birds. *Proc Annu Conf Assoc Avian Vet*; 1998:213–216.

360. Hoppes S, Flammer K, Hoersch K, et al. Disposition and analgesic effects of fentanyl in white cockatoos (*Cacatua alba*). *J Avian Med Surg*. 2003;17:124–130.

361. Howard LL, Papendick R, Stalis IH, et al. Fenbendazole and albendazole toxicity in pigeons and doves. *J Avian Med Surg*. 2002;16:203–210.

362. Hu J, McDougald LR. The efficacy of some drugs with known antiprotozoal activity against *Histomonas meleagridis* in chickens. *Vet Parasitol*. 2004;121:233–238.

363. Huckabee JR. Raptor therapeutics. *Vet Clin North Am Exotic Anim Pract*. 2000;3:91–116.

364. Hudelson KS. A review of the mechanisms of avian reproduction and their clinical applications. *Semin Avian Exotic Pet Med*. 1996;5:189–198.

365. Huff DG. Avian fluid therapy and nutritional therapeutics. *Semin Avian Exotic Pet Med*. 1993;2:13–16.

366. Iglauer F, Rasim R. Treatment of psychogenic feather picking in psittacine birds with a dopamine antagonist. *J Small Anim Pract*. 1993;34:564–566.

367. Inghelbrecht S, Vermeersch H, Ronsmans S, et al. Pharmacokinetics and anti-trichomonal efficacy of a dimetridazole tablet and water-soluble powder in homing pigeons (*Columba livia*). *J Vet Pharmacol Therap*. 1996;19:62–67.

368. Ingram K. Hummingbirds and miscellaneous orders. In: Fowler ME, ed. *Zoo and Wild Animal Medicine*. 2nd ed. Philadelphia: WB Saunders; 1986:447–456.



369. International Species Information System (ISIS) Discussion Forum.  
<http://forums.isis.org/forums>, 2003. Accessed 11 Nov 2003
370. Isaza R, Budsberg SC, Sundlof SF, et al. Disposition of ciprofloxacin in red-tailed hawks following a single oral dose. *J Zoo Wildl Med*. 1993;24:498–502.
371. Islam KMS, Klein U, Burch DGS. The activity and compatibility of the antibiotic tiamulin with other drugs in poultry medicine—a review. *Poult Sci*. 2009;88:2353–2359.
372. Itoh N, Okada H. Pharmacokinetics and tolerability of chloramphenicol in budgerigars (*Melopsittacus undulatus*). *J Vet Med Sci*. 1993;55:439–442.
373. Jaensch SM, Cullen L, Raidal SR. Assessment of liver function in galahs after partial hepatectomy. a comparison of plasma enzyme concentrations, serum bile acid levels, and galactose clearance tests. *J Avian Med Surg*. 2000;14:164–171.
374. Jalanka H. New alpha two adrenoceptor agonists and antagonists. Fowler ME, ed. *Zoo and Wild Animal Medicine. Current Therapy*. 3rd ed. Philadelphia: WB Saunders Co; 1993:475–476.
375. Jalanka HH. Medetomidine-ketamine and atipamezole. a reversible method for chemical restraint of birds. *Proc First Annu Conf Euro Comm Assoc Avian Vet*; 1991:102–104.
376. James SB, Sheppard C, Arland M, et al. The use of medetomidine as an oral sedative in galliformes. *Proc Annu Conf Am Assoc Zoo Vet*; 1999:293–294.
377. Janovsky M, Ruf T, Wolfgang Z. Oral administration of tiletamine/zolazepam for the immobilization of the common buzzard (*Buteo buteo*). *J Raptor Res*. 2002;36:188–193.
378. Jenkins JR. Postoperative care of the avian patient. *Semin Avian Exotic Pet Med*. 1993;2:97–102.
379. Jenkins JR. Avian critical care and emergency medicine. In: Altman RB, Clubb SL, Dorrestein GM, et al. *Avian Medicine and Surgery*. Philadelphia: WB

Saunders Co; 1997:839–863.

380. Jenkins JR. Feather picking and self-mutilation in psittacine birds. *Vet Clin North Am Exotic Anim Pract.* 2001;4:663–667.

381. Jenkins JR. Personal communication; 2003.

382. Jennings IB. Haematology. In: Beynon PH, Forbes NA, Harcourt-Brown NH. *BSAVA Manual of Raptors, Pigeons and Waterfowl*. Ames: Iowa State University Press; 1996:68–78.

383. Jensen J, Westerman E. Amikacin pharmacokinetics in ostrich (*Struthio camelus*). *Proc Annu Conf Am Assoc Zoo Vet*; 1990:238–242.

384. Jensen JM, Johnson JH, Weiner ST. *Husbandry & Medical Management of Ostriches, Emus & Rheas*. College Station, TX: Wildlife and Exotic Animal TeleConsultants; 1992.

385. Jeong MB, Kim YG, Yi NY, et al. Comparison of the rebound tonometer (TonoVet) with the applanation tonometer (TonoPen XL) in normal Eurasian eagle owls (*Bubo bubo*). *Vet Ophthalmol.* 2007;10:376–379.

386. Jin S, Sell JL. Dietary vitamin K1 requirements and comparison of biopotency of different vitamin K sources for young turkeys. *Poult Sci.* 2001;80:615–620.

387. Johnson-Delaney CA, Harrison LR. *Exotic Companion Medicine Handbook for Veterinarians*. Lake Worth, FL: Wingers Publishing, 1996.

388. Johnson-Delaney CA. *Exotic Companion Medicine Handbook for Veterinarians*. Lake Worth, Fl: Zoological Education Network; 2005. edition [www.exoticdvm.com](http://www.exoticdvm.com)

389. Johnston M. Personal communication; 2003.

390. Johnston MS, Ivey ES. Parathyroid and ultimobranchial glands. calcium metabolism in birds. *Semin Avian Exotic Pet Med.* 2002;11:84–93.

391. Jones MP. Selected diseases of birds of prey. Proc Annu Meet Am Board Vet Pract; 2001:31–39.
392. Jones MP. Selected infectious diseases of birds of prey. *J Exotic Pet Med*. 2006;15:5–17.
393. Jones MP, Orosz SE. Overview of avian neurology and neurological diseases. *Semin Avian Exotic Pet Med*. 1996;5:150–164.
394. Jones MP, Orosz SE, Cox SK, et al. Pharmacokinetic disposition of itraconazole in red-tailed hawks (*Buteo jamaicensis*). *J Avian Med Surg*. 2000;14:15–22.
395. Jordan FTW, Horrocks BK. The minimum inhibitory concentration of tilmicosin and tylosin for *Mycoplasma gallisepticum* and *Mycoplasma synoviae* and a comparison of their efficacy in the control of *Mycoplasma gallisepticum* infection in chickens. *Avian Dis*. 1997;41:802–807.
396. Joseph V. Raptor pediatrics. *Semin Avian Exotic Pet Med*. 1993;2:142–151.
397. Joseph V. Preventive health programs for falconry birds. Proc Annu Conf Assoc Avian Vet; 1995:171–178.
398. Joseph V. Selected medical topics for birds of prey. Proc Annu Conf Assoc Avian Vet; 1996:261–266.
399. Joseph V. Emergency care of raptors. *Vet Clin North Am Exotic Anim Pract*. 1998;1:77–98.
400. Joseph V, Pappagianis D, Reavill DR. Clotrimazole nebulization for the treatment of respiratory aspergillosis. Proc Annu Conf Assoc Avian Vet; 1994:301–306.
401. Joyner K. Psittacine incubation and pediatrics. In: Fowler ME, ed. *Zoo and Wild Animal Medicine: Current Therapy*. 3rd ed. Philadelphia: WB Saunders; 1993:247–260.
402. Joyner KL. Pediatric therapeutics. Proc Annu Conf Assoc Avian Vet;

1991:188–199.

403. Joyner PH, Jones MP, Ward D, et al. Induction and recovery characteristics and cardiopulmonary effects of sevoflurane and isoflurane in bald eagles. *Am J Vet Res*. 2008;69:13–22.

404. Juarbe-Diaz SJ. Animal behavior case of the month. *J Am Vet Med Assoc*. 2000;216:1562–1564.

405. Junge RE, Naeger LL, LeBeau MA, et al. Pharmacokinetics of intramuscular and nebulized ceftriaxone in chickens. *J Zoo Wildl Med*. 1994;25:224–228.

406. Kahler J. Somatostatin treatment for diabetes mellitus in a sulfur breasted toucan. *Proc Annu Conf Assoc Avian Vet*; 1994:269–273.

407. Kahler J. The use of gallium scanning in psittacine birds. *Proc Annu Conf Assoc Avian Vet*; 2001:91–93.

408. Kamiloglu A, Atalan G, Kamiloglu NN. Comparison of intraosseous and intramuscular drug administration for induction of anaesthesia in domestic pigeons. *Res Vet Sci*. 2008;85:171–175.

409. Kasper A. Rehabilitation of California towhees. *Proc Annu Conf Assoc Avian Vet*; 1997:83–90.

410. Kaufman E, Pokras M, Sedgwick C. IME-Anesthesia in waterfowl. *AAV Today*. 1988;2:98.

411. Kaufman GE. Avian emergencies. In: Murtaugh RJ, Kaplan PM. *Veterinary Emergency and Critical Care Medicine*. St Louis: Mosby Year Book, Inc; 1992:453–463.

412. Kearns KS. Paroxetine therapy for feather picking and self-mutilation in the waldrapp ibis (*Genonticus eremita*). *Proc Joint Conf Am Assoc Zoo Vet/Am Assoc Wildl Vet/Wildl Dis Assoc*; 2004:254–255.

413. Keffen R. The ostrich. capture, care, accommodation, and transportation. McKenzie A, ed. *Capture and Care Manual*. Pretoria, South Africa: Wildlife

Decision Services; 1993:634–652.

414. Keitzmann M, Knoll U, Glünder G. Pharmacokinetics of enrofloxacin and danofloxacin in broiler chickens. *J Vet Pharmacol Therap.* 1997;20(Suppl 1):202.

415. Keller D, Sanchez-Migallon Guzman D, Kukanich B, et al. Pharmacokinetics of nalbuphine hydrochloride after intravenous and intramuscular administration to Hispaniolan Amazon parrots (*Amazona ventralis*). *Am J Vet Res.* 2011;72:741–745.

416. Kempf I, Reeve-Johnson L, Gesbert F, et al. Efficacy of tilmicosin in the control of experimental *Mycoplasma gallisepticum* infection in chickens. *Avian Dis.* 1997;41:802–807.

417. Keymer I. Pigeons. In: Beynon P, Cooper J. *BSAVA Manual of Exotic Pets*. Ames: Iowa State University Press; 1991:180–202.

418. Kirkwood J. Management-related diseases. In: Samour J, ed. *Avian Medicine*. London: Harcourt Publishers Limited; 2000:170–218.

419. Klaphake E, Fecteau K, DeWit M, et al. Effects of leuprolide acetate on selected blood and fecal sex hormones in Hispaniolan Amazon parrots (*Amazona ventralis*). *J Avian Med Surg.* 2009;23:253–262.

420. Klaphake E, Schumacher J, Greenacre C, et al. Comparative anesthetic and cardiopulmonary effects of pre- versus postoperative butorphanol administration in Hispaniolan Amazon parrots (*Amazona ventralis*) anesthetized with sevoflurane. *J Avian Med Surg.* 2006;20:2–7.

421. Klein PN, Charmatz K, Langenberg J. The effect of flunixin meglumine (Banamine®) on the renal function in northern bobwhite (*Colinus virginianus*). an avian model. *Proc Annu Conf Am Assoc Zoo Vet*; 1994:128–131.

422. Knoll U, Glunder G, Kietzmann M. Comparative study of the plasma pharmacokinetics and tissue concentrations of danofloxacin and enrofloxacin in broiler chickens. *J Vet Pharmacol Ther.* 1999;22:239–246.

423. Koepff C. *The New Finch Handbook*. Woodbury, NY: Barron's Educational

Series; 1983.

424. Kollias GV. Nutritional support for captive wild birds. Proc Annu Conf Am Assoc Zoo Vet; 1993:23–24.

425. Kollias GV, Jr., Palgut J, Rossi J, et al. The use of ketoconazole in birds. preliminary pharmacokinetics and clinical applications. Proc Annu Conf Assoc Avian Vet; 1986:103.

426. Kollias GV, Zgola MM, Weinkle TK, et al. Amikacin sulfate pharmacokinetics in ring-necked pheasants (*Phasianus colchicus*). age and route dependent effects. Proc Annu Conf Am Assoc Zoo Vet; 1996:178–180.

427. Korbelt R. Inhalation anaesthesia with isoflurane (Forene®) and sevoflurane (SEVOrane®) in domestic pigeons (*Columba livia*, Gmel., 1789, var. domestica). Ger Vet Med Soc; 1998:209–217.

428. Korbelt RT. Avian ophthalmology. principles and application. Proc Annu Conf Assoc Avian Vet; 1997:305–315.

429. Korbelt RT. Investigations into intraocular injection of recombinant tissue plasminogen activator (rTPA) for the treatment of trauma-induced intraocular hemorrhages in birds. Proc Annu Conf Assoc Avian Vet; 2003:97.

430. Korbelt RT, Goetz B. Investigations on topical anesthesia of the eye in racing pigeons (*Columba livia*) and common buzzards (*Buteo buteo*). Proc Annu Conf Assoc Avian Vet; 2001:51–53.

431. Koustos EA, Tell LA, Woods LW, et al. Adult cockatiels (*Nymphicus hollandicus*) at maintenance are more sensitive to diets containing excess vitamin A than to vitamin A-deficient diets. *J Nutr.* 2003;133:1898–1902.

432. Krautwald ME, Pieper K, Ruloff R, et al. Further experiences with the use of Baytril in pet birds. Proc Annu Conf Assoc Avian Vet; 1990:226–236.

433. Krautwald-Junghanns ME, Straub J. Avian Cardiology. Part I. Proc Annu Conf Assoc Avian Vet; 2001:323–330.

434. Krautwald-Junghanns ME, Zebisch R, Schmidt V. Relevance and treatment of coccidiosis in domestic pigeons (*Columba livia forma domestica*) with particular emphasis on toltrazuril. *J Avian Med Surg*. 2009;23:1–5.
435. Kreeger TJ, Degernes LA, Kreeger JS, et al. Immobilization of raptors with tiletamine and zolazepam (Telazol). In: Redig PT, Cooper JE, Remple DJ, et al. *Raptor Biomedicine*. Minneapolis: University of Minnesota Press; 1993:141–144.
436. Krinsley M. IME—Use of DermCaps Liquid and hydroxyzine HCl for the treatment of feather picking. *J Assoc Avian Vet*. 1993;7:221.
437. LaBonde J. Toxicity in pet avian patients. *Semin Avian Exotic Pet Med*. 1995;4:23–31.
438. LaBonde J. Private collections of waterfowl. *Proc Annu Conf Assoc Avian Vet*; 1996:215–224.
439. Laczay P, Semjén G, Nagy G, et al. J. Comparative studies on the pharmacokinetics of norfloxacin in chickens, turkeys, and geese after a single oral administration. *J Vet Pharmacol Therap*. 1998;21:161–164.
440. Lane R. Basic techniques in pet avian clinical pathology. *Vet Clin North Am Small Anim Pract*. 1991;21:1157–1179.
441. Langan JN, Ramsay EC, Blackford JT, et al. Cardiopulmonary and sedative effects of intramuscular medetomidine-ketamine and intravenous propofol in ostriches (*Struthio camelus*). *J Avian Med Surg*. 2000;14:2–7.
442. Langenberg JA, Businga NK, Nevill HE. Capture of wild sandhill cranes with alpha-chloralose. techniques and physiologic effects. *Proc Joint Conf Am Assoc Zoo Vet/Am Assoc Wildl Vet*; 1998:50–53.
443. Langlois I, Harvey RC, Jones MP, et al. Cardiopulmonary and anesthetic effects of isoflurane and propofol in Hispaniolan Amazon parrots. *J Avian Med Surg*. 2003;17:4–10.
444. Lashev LD, Mihailov R. Pharmacokinetics of apramycin in Japanese quail. *J Vet Pharmacol Therap*. 1994;17:394–395.

445. Lawton MPC. Anaesthesia. In: Beynon PH, Forbes NA, Lawton MPC. *BSAVA Manual of Psittacine Birds*. Ames: Iowa State University Press; 1996:49–55.
446. Lawton MPC. Anaesthesia. In: Beynon PH, Forbes NA, Harcourt-Brown NH. *BSAVA Manual of Raptors, Pigeons and Waterfowl*. Ames: Iowa State University Press; 1996:79–88.
447. Legler M, Kothe R, Rautebschlein S, et al. Detection of psittacid herpesvirus 1 in Amazon parrots with cloacal papilloma [internal papillomatosis of parrots, IPP] in an aviary of different psittacine species. *Dtsch Tierarztl Wochenschr*. 2008;115:461–470.
448. Lehmkul RC, Almedia MF, Mamprim MJ, et al. B-mode ultrasonography biometry of the Amazon parrot (*Amazona aestiva*) eye. *Vet Ophthalmol*. 2010;13:26–28. Suppl
449. Lennox AM. Long-term use of haloperidol in two parrots. *Proc Annu Conf Assoc Avian Vet*; 1999:133–137.
450. Lennox AM. Successful treatment of mycobacteriosis in three psittacine birds. *Proc Annu Conf Assoc Avian Vet*; 2002:111–113.
451. Lennox AM. The use of Aldara™ (imiquimod) for the treatment of cloacal papillomatosis in psittacines. *Exotic DVM*. 2002;4:34–35.
452. Lennox AM. Mycobacteriosis in companion psittacine birds. a review. *J Avian Med Surg*. 2007;21:181–187.
453. Lennox AM, VanDerHeyden N. Haloperidol for use in treatment of psittacine self-mutilation and feather plucking. *Proc Annu Conf Assoc Avian Vet*; 1993:119–120.
454. Levy A, Perelman B, Waner T, et al. Reference blood chemical values in ostriches (*Struthio camelus*). *Am J Vet Res*. 1989;50:1548–1550.
455. Lichtenberger M. Treatment of respiratory inhalant toxins in 4 psittacine birds. *Proc Annu Conf Assoc Avian Vet*; 2003:39–43.



456. Lichtenberger M, Ko J. Critical care monitoring. *Vet Clin North Am Exotic Anim Pract.* 2007;10:317–344.
457. Lichtenberger M, Chavez W, Cray C, et al. Mortality and response to fluid resuscitation after acute blood loss in mallard ducks. *Proc Annu Conf Assoc Avian Vet*; 2003:7–10.
458. Lichtenberger M, Lennox A, Chavez W, et al. The use of butorphanol constant rate infusion in psittacines. *Proc Annu Conf Assoc Avian Vet/Assoc Exotic Mam Vet*; 2009:73.
459. Lichtenberger M, Rosenthal K, Brue R, et al. Administration of Oxyglobin and 6% hetastarch after acute blood loss in psittacine birds. *Proc Annu Conf Assoc Avian Vet*; 2001:15–18.
460. Lierz M. Use of inhalation chamber for aspergillosis therapy. *Exotic DVM.* 2000;2:79–80.
461. Lightfoot TL. Clinical use and preliminary data of chorionic gonadotropin administration in psittacines. *Proc Annu Conf Assoc Avian Vet*; 1996:303–306.
462. Lightfoot TL. How I approach chronic egg laying. *Proc North Am Vet Conf*; 1998:757–760.
463. Lightfoot TL. Hyaluronidase. therapeutic applications including egg-yolk disease. *Proc Annu Conf Assoc Avian Vet*; 2000:17–21.
464. Limoges M-J, Semple HA, Wheler CL, et al. Plasma pharmacokinetics of an orally administered azithromycin in mealy Amazons (*Amazona farinosa*). *Proc Annu Conf Assoc Avian Vet*; 1998:41–43.
465. Lin E, Luscombe C, Colledge G, et al. Long-term therapy with the guanine nucleoside analog penciclovir controls chronic duck hepatitis B virus infection in vivo. *Antimicrob Agents Chemother.* 1998;42:2132–2137.
466. Lin HC, Todhunter PG, Power TA, et al. Use of xylazine, butorphanol, tiletamine-zolazepam, and isoflurane for induction and maintenance of anesthesia in ratites. *J Am Vet Med Assoc.* 1997;210:244–248.

467. Lindenstruth H, Frost JW. Enrofloxacin (Baytril)- an alternative for psittacosis prevention and therapy in imported psittacines. *DTW Dtsch Tierarztl Wochenschr.* 1993;100:364–368.
468. Locke D, Bush M. Tylosin aerosol therapy in quail and pigeons. *J Zoo Anim Med.* 1984;15:67–72.
469. Locke D, Bush M, Carpenter JW. Pharmacokinetics and tissue concentrations of tylosin in selected avian species. *Am J Vet Res.* 1982;43:1807–1810.
470. Loerzel SM, Smith PJ, Howe A, et al. Vecuronium bromide, phenylephrine and atropine combinations as mydriatics in juvenile double-crested cormorants (*Phalacrocorax auritus*). *Vet Ophthalmol.* 2002;5:149–154.
471. Lohr JE, Haberkorn A. Efficacy of toltrazuril against natural infections with intestinal coccidia in aviary birds. *Praktische-Tierarzt.* 1998;79:419–422.
472. Loibl MF, Clutton RE, Marx BD, et al. Alpha-chloralose as a capture and restraint agent of birds. therapeutic index determination in the chicken. *J Wildl Dis.* 1988;24:684–687.
473. Lothrop CD, Loomis MR, Olsen JH. Thyrotropin stimulation test for evaluation of thyroid function in psittacine birds. *J Am Vet Med Assoc.* 1985;186:47–48.
474. Lothrop CD, Olsen JH, Loomis MR, et al. Evaluation of adrenal function in psittacine birds using ACTH. *J Am Vet Med Assoc.* 1985;187:1113–1115.
475. Lublin A, Raz C, Weisman Y. Excretion of Baytril (enrofloxacin) in pigeon milk as an approach to treat squabs. *Israel J Vet Med.* 1996;51:125–128.
476. Lublin Z, Mechani S, Malkinson M, et al. Efficacy of norfloxacin nicotinate treatment of broiler breeders against *Haemophilus paragallinarum*. *Avian Dis.* 1993;37:673–679.
477. Ludders JW, Mitchell GS, Rode J. Minimal anesthetic concentration and cardiopulmonary dose response of isoflurane in ducks. *Vet Surg.* 1990;19:304–307.

478. Ludders JW, Rode J, Mitchell GS. Isoflurane anesthesia in sandhill cranes (*Grus canadensis*). minimal anesthetic concentration and cardiopulmonary dose-response during spontaneous and controlled breathing. *Anesth Analg*. 1989;68:511–516.
479. Ludders JW, Rode J, Mitchell GS, et al. Effects of ketamine, xylazine, and a combination of ketamine and xylazine in Pekin ducks. *Am J Vet Res*. 1989;50:245.
480. Lumeij JT. Appendix. hematology and biochemistry-Columbiformes. Ritchie BW, Harrison GJ, Harrison LR. *Avian Medicine: Principles and Application*. Lake Worth, FL: Wingers Publ; 1994:1339–1340.
481. Lumeij JT. Psittacine antimicrobial therapy. *Antimicrobial Therapy in Caged Birds and Exotic Pets*. Trenton: Veterinary Learning Systems Co; 1995:38–48.
482. Lumeij JT. Avian clinical biochemistry. In: Kaneko JJ, Harvey JW, Bruss ML. *Clinical Biochemistry of Domestic Animals*. San Diego: Academic Press; 1997:857–884.
483. Lumeij JT, Gorgevska D, Woestenborghs R. Plasma and tissue concentrations of itraconazole in racing pigeons (*Columba livia domestica*). *J Avian Med Surg*. 1995;9:32–35.
484. Lumeij JT, Redig PT, Sprang EPM. Further studies on allopurinol induced hyperuricaemia and visceral gout in red-tailed hawks. *Avian Path*. 1998;27:390–393.
485. Lung NP, Romagnano A. Current approaches to feather picking. In: Bonagura JD, ed. *Kirk's Current Veterinary Therapy XII: Small Animal Practice*. Philadelphia: WB Saunders Co; 1995:1303–1307.
486. Lupu CA. Evaluation of side effects of tamoxifen in budgerigars. *J Avian Med Surg*. 2000;14:237–242.
487. Machin KL, Caulkett NA. Cardiopulmonary effects of propofol and a medetomidine-midazolam-ketamine combination in mallard ducks. *Am J Vet Res*. 1998;59:598–602.

488. Machin KL, Caulkett NA. Investigation of injectable anesthetic agents in mallard ducks (*Anas platyrhynchos*). a descriptive study. *J Avian Med Surg*. 1998;12:255–262.
489. Machin KL, Caulkett NA. Cardiopulmonary effects of propofol infusion in canvasback ducks (*Aythya valisineria*). *J Avian Med Surg*. 1999;13:167–172.
490. Machin KL, Caulkett NA. Evaluation of isoflurane and propofol anesthesia for intraabdominal transmitter placement in nesting female canvasback ducks. *J Wildl Dis*. 2000;36:324–334.
491. Machin KL, Livingston A. Plasma bupivacaine levels in mallard ducks (*Anas platyrhynchos*) following a single subcutaneous dose. Proc Annu Conf Am Assoc Zoo Vet/Am Assoc Wildl Vet/Assoc Rept Amph Vet/Nat Assoc Zoo Wildl Vet; 2001:159–163.
492. Machin KL, Livingston A. Assessment of the analgesic effects of ketoprofen in ducks anesthetized with isoflurane. *Am J Vet Res*. 2002;63:821–826.
493. Machin KL, Tellier LA, Lair S, et al. Pharmacodynamics of flunixin and ketoprofen in mallard ducks (*Anas platyrhynchos*). *J Zoo Wildl Med*. 2001;32:222–229.
494. Macwhirter P. Passeriformes. In: Ritchie RW, Harrison GJ, Harrison LR. *Avian Medicine: Principles and Application*. Lake Worth, FL: Wingers Publ; 1994:1172–1199.
495. Macwhirter P, Pyke D, Wayne J. Use of carboplatin in the treatment of renal adenocarcinoma in a budgerigar. *Exotic DVM*. 2002;4:11–12.
496. Mader JT, Calhoun J, Cobos J. In vitro evaluation of antibiotic diffusion from antibiotic-impregnated biodegradable beads and polymethylmethacrylate beads. *Antimicrob Agents Chemother*. 1997;41:415–418.
497. Mainka SA, Dierenfeld ES, Cooper RM, et al. Circulating a-tocopherol following intramuscular or oral vitamin E administration in Swainson's hawks (*Buteo swainsonii*). *J Zoo Wildl Med*. 1994;25:229–232.

498. Maiti SK, Tiwary R, Vasan P, et al. Xylazine, diazepam and midazolam premedicated ketamine anaesthesia in white Leghorn cockerels for typhlectomy. *J S Afr Vet Assoc*. 2006;77:12–18.
499. Malkinson M, Banet C, Khinich Y, et al. Use of live and inactivated vaccines in the control of West Nile fever in domestic geese. *Annals New York Acad Sci*. 2001;951:255–261.
500. Malley AD. Practical therapeutics for cage and aviary birds. In: Raw ME, Parkinson TJ. *The Veterinary Annual*. London: Blackwell Scientific Publ; 1994:235–246.
501. Mama KR, Phillips LG, Pascoe PJ. Use of propofol for induction and maintenance of anesthesia in a barn owl (*Tyto alba*) undergoing tracheal resection. *J Zoo Wildl Med*. 1996;27:397–401.
502. Mandelker L. Avian anesthesia, part II. injectable agents. *Compan Anim Pract*. 1988;2:21.
503. Mans C, Sanchez-Migallon Guzman D, Lahner LL, et al. Intranasal midazolam for conscious sedation in Hispaniolan Amazon parrots (*Amazona ventralis*). *Proc Annu Conf Am Assoc Zoo Vet*; 2010:160.
504. Marangi M, Cafiero MA, Capelli G, et al. Evaluation of the poultry red mite, *Dermanyssus gallinae* (Acari: Dermanyssidae) susceptibility to some acaricides in field populations from Italy. *Exp Appl Acarol*. 2009;48:11–18.
505. Marshall KL, Craig LE, Jones MP, et al. Quantitative renal scintigraphy in domestic pigeons (*Columba livia domestica*) exposed to toxic doses of gentamicin. *Am J Vet Res*. 2003;64:453–462.
506. Marshall R. Avian anthelmintics and antiprotozoals. *Semin Avian Exotic Pet Med*. 1993;2:33–41.
507. Martin HD, Kollias GV. Evaluation of water deprivation and fluid therapy in pigeons. *J Zoo Wildl Med*. 1989;20:173–177.
508. Martin KM. Psittacine behavioral pharmacotherapy. In: Leuscher AU, ed.

*Manual of Parrot Behavior*. Ames: Blackwell Publishing; 2006:267–280.

509. Martinez R, Wobeser G. Immunization of ducks for type C botulism. *J Wildl Dis*. 1999;35:710–715.

510. Marx D. Preventive health care with diagnostics. *AAV Today*. 1988;2:92–94.

511. Marx KL, Roston MA. The Exotic Animal Drug Compendium. An International Formulary. Trenton: Veterinary Learning Systems; 1996.

512. Mashima TY, Ley DH, Stoskopf MK, et al. Evaluation of treatment of conjunctivitis associated with *Mycoplasma gallisepticum* in house finches (*Carpodacus mexicanus*). *J Avian Med Surg*. 1997;11:20–24.

513. Massey JG. Diseases and medical management of wild passeriformes. *Semin Avian Exotic Pet Med*. 2003;12:29–36.

514. Massey JG, Work TM. Diclazuril therapy for clinical toxoplasmosis. *Proc Annu Conf Assoc Avian Vet*; 2000:29–39.

515. Matthews NS. Anesthesia for big birds (ostriches and emus). *Proc North Am Vet Conf*; 1993:705.

516. Mazet JAK, Newman SH, Gilardi KVK, et al. Advances in oiled bird emergency medicine and management. *J Avian Med Surg*. 2002;16:146–149.

517. McDonald SE. IME—Injecting eggs with antibiotics. *J Assoc Avian Vet*. 1989;1:9.

518. McDonald SE. IME—Summary of medications for use in psittacine birds. *J Assoc Avian Vet*. 1989;3:120–127.

519. McGeown D, Danbury TC, Waterman-Pearson AE, et al. Effect of carprofen on lameness in broiler chickens. *Vet Rec*. 1999;144:668–671.

520. McMillan MC. Avian gastrointestinal radiography. In: Hoefer HL, ed. *Practical Avian Medicine: The Compendium Collection*. Trenton: Veterinary Learning Systems Co; 1997:24–29.

521. Menao MC, Bottino JA, Biasia I, et al. Salmonella typhimurium infection in hyacinth macaw (*Anodorhynchus hyacinthinus*). *Arquivos-do-Instituto-Biologico-Sao-Paulo*. 2000;67:43–47.
522. Merryman JI, Buckles EL. The avian thyroid gland. *J Avian Med Surg*. 1998;12:234–242.
523. Mertens PA. Pharmacological treatment of feather picking in pet birds. *Euro Soc Vet Clin Ethol Newsl*. 1997;3. <http://www.esvce.org/newsletter/esvce-97-1.html>. 4/5, Internet version 1.1
524. Meteyer CU, Rideout BA, Gilbert M, et al. Pathology and proposed pathophysiology of diclofenac poisoning in free-living and experimentally exposed oriental white-backed vultures (*Gyps bengalensis*). *J Wildl Dis*. 2005;41:707–716.
525. Migaki TT, Avakian AP, Barnes HJ, et al. Efficacy of danofloxacin and tylosin in the control of mycoplasmosis in chicks infected with tylosin-susceptible or tylosin-resistant field isolates of *Mycoplasma gallisepticum*. *Avian Dis*. 1993;37:508–514.
526. Mikaelian I, Paillet I, Williams D. Comparative use of various mydriatic drugs in kestrels (*Falco tinnunculus*). *Am J Vet Res*. 1994;55:270–272.
527. Millam JR. Leuprolide acetate can reversibly prevent egg laying in cockatiels. *Proc Annu Conf Assoc Avian Vet*; 1993:46.
528. Millam JR, Finney HL. Leuprolide acetate can reversibly prevent egg laying in cockatiels (*Nymphicus hollandicus*). *Zoo Biol*. 1994;13:149–155.
529. Miller EA, Welte SC. Caring for oiled birds. In: Fowler ME, Miller RE. *Zoo and Wild Animal Medicine: Current Therapy 4*. Philadelphia: WB Saunders Co; 1998:300–309.
530. Miller MS. Electrocardiography. In: Harrison GJ, Harrison LR. *Clinical Avian Medicine and Surgery*. Philadelphia: WB Saunders Co; 1986:286–292.
531. Mitchell MA, Tully TN, JR. Birds. In. *Manual of Exotic Pet Practice*. St.

Louis: Saunders/Elsevier; 2009:250–298.

532. Mohan R. Mycoplasma in ratites. *Proc Annu Conf Assoc Avian Vet*; 1993:294–296.

533. Molter CM, Court MH, Hazarika S, et al. Pharmacokinetics of parenteral and oral meloxicam in Hispaniolan parrots (*Amazona ventralis*). *Proc Annu Conf Assoc Avian Vet/Assoc Exotic Mam Vet*; 2009:317–318.

534. Moore DM, Rice RL. Exotic animal formulary. In: Holt KM, Boothe DM, Gaumnitz J, et al. *Veterinary Values*. 5th ed. Lenexa, KS: Veterinary Medicine Publishing Group; 1998:159–245.

535. Moore RP, Snowden KF, Phalen DN, et al. Diagnosis, treatment, and prevention of megabacteriosis in the budgerigar (*Melopsittacus undulatus*). *Proc Annu Conf Assoc Avian Vet*; 2001:161–163.

536. Morishita TY. Clinical assessment of gallinaceous birds and waterfowl in backyard flocks. *Vet Clin North Am Exotic Anim Pract*. 1999;2:383–404.

537. Morrissey JK. Avian emergency medicine and critical care. In: Hoefer HL, ed. *Practical Avian Medicine: The Compendium Collection*. Trenton, NJ: Veterinary Learning Systems Co; 1997:53–57.

538. Morrissey JK, Hohenhaus AE, Rosenthal K, et al. Comparison of three media for the storage of avian whole blood. *Proc Annu Conf Am Assoc Zoo Vet*; 1998:149–150.

539. Mostachio GQ, de-Oliveira LD GQ, Carciofi AC, et al. The effects of anesthesia with a combination of intramuscular xylazine-diazepam-ketamine on heart rate, respiratory rate and cloacal temperature in roosters. *Vet Anaesth Analg*. 2008;35:232–236.

540. Muir W, Hubbel J. *Handbook of Veterinary Anesthesia*. 2nd ed. St. Louis: Mosby; 1995:341–371.

541. Mulcahy DM, Stoskopf MK, Esler D. Lack of isoflurane-sparing effect of butorphanol in field anesthesia of harlequin ducks (*Histrionicus histrionicus*). *Proc*



Annu Conf Am Assoc Zoo Vet/Internat Assoc Aquatic Anim Med; 2000:532–533.

542. Mulcahy DM, Tuomi P, Larsen RS. Differential mortality of male spectacled eiders (*Somateria fischeri*) and king eiders (*Somateria spectabilis*) subsequent to anesthesia with propofol, bupivacaine, and ketoprofen. *J Avian Med Surg*. 2003;17:117–123.

543. Muller MG, Kinne J, Schuster RK, et al. Outbreak of microsporidiosis caused by *Enterocytozoon bieneusi* in falcons. *Vet Parasitol*. 2008;152:67–78.

544. Murai A, Furuse M, Okumura J-I. Involvement of (n-6) essential fatty acids and prostaglandins in liver lipid accumulation in Japanese quail. *Am J Vet Res*. 1996;57:342–345.

545. Murase T, Ikeda T, Goto I, et al. Treatment of lead poisoning in wild geese. *J Am Vet Med Assoc*. 1992;200:1726–1729.

546. Murphy CJ. Raptor ophthalmology. *Compend Contin Educ Pract Vet*. 1987;9:241–260.

547. Murphy J. Diabetes in toucans. *Proc Annu Conf Assoc Avian Vet*; 1992:165–170.

548. Murphy J. Psittacine trichomoniasis. *Proc Annu Conf Assoc Avian Vet*; 1992:21–24.

549. Murray M, Tseng F. Diagnosis and treatment of secondary anticoagulant rodenticide toxicosis in a red-tailed hawk (*Buteo jamaicensis*). *J Avian Med Surg*. 2008;22:41–46.

550. Murray MJ. Management of the avian trauma case. *Semin Avian Exotic Pet Med*. 1994;3:200–209.

551. Mutlow A, Forbes N. Haemoproteus in raptors. pathogenicity, treatment, and control. *Proc Annu Conf Assoc Avian Vet*; 2000:157–163.

552. Naccari F, Salpietro DC, DeSarro A, et al. Tolerance and pharmacokinetics of

ciprofloxacin in the chick. Preliminary experience in subjects of pediatric age with urinary tract infections. *Res Commun Mol Pathol Pharmacol*. 1998;99:187–192.

553. Naether CA. *Raising Pigeons and Doves*. New York: David McKay Co; 1979.

554. Naganobu K, Fujisawa Y, Ohde H, et al. Determination of the minimum anesthetic concentration and cardiovascular dose response for sevoflurane in chickens during controlled ventilation. *Vet Surg*. 2000;29:102–105.

555. Naidoo V, Swan GE. Diclofenac toxicity in Gyps vulture is associated with decreased uric acid excretion and not renal portal vasoconstriction. *Comp Biochem Physiol C Toxicol Pharmacol*. 2008;149:269–274.

556. Naidoo V, Venter L, Wolter K, et al. The toxicokinetics of ketoprofen in Gyps coprotheres. toxicity due to zero-order metabolism. *Arch Toxicol*. 2010;84:761–766.

557. Naidoo V, Wolter K, Cromarty AD, et al. The pharmacokinetics of meloxicam in vultures. *J Vet Pharmacol Ther*. 2008;31:128–134.

558. Naidoo V, Wolter K, Cromarty D, et al. Toxicity of non-steroidal anti-inflammatory drugs to Gyps vultures. a new threat from ketoprofen. *Biol Lett*. 2010;6:339–341.

559. Napier JE, Hinrichs SH, Lampen F, et al. An outbreak of avian mycobacteriosis caused by Mycobacterium intracellulare in little blue penguins (Eudyptula minor). *J Zoo Wildl Med*. 2009;40:680–686.

560. National Association of State Public Health Veterinarians. Compendium of measures to control Chlamydophila psittaci infection among humans and pet birds, 2002. recommendations and requirements. *Compend Contin Educ Pract Vet*. 2002;24:374–379.

561. National Registration Authority for Agricultural and Veterinary Chemicals. Dimetridazole Scope Document. Canberra, Australia.  
[http://www.apvma.gov.au/chemrev/dimetridazole\\_scope.pdf](http://www.apvma.gov.au/chemrev/dimetridazole_scope.pdf), 2002.

562. National Research Council. *Nutrient Requirements of Poultry*. Washington, DC: National Academy Press; 1994.
563. Nazifi S, Nabinejad A, Sepehrimanesh M, et al. Haematology and serum biochemistry of golden eagle (*Aquila chrysaetos*) in Iran. *Comp Clin Pathol*. 2008;17:197–201.
564. Nemetz LP, Lennox AM. Zosyn. a replacement for Pipracil in the avian patient. *Proc Annu Conf Assoc Avian Vet*; 2004:11–13.
565. Neut D, van de Belt H, van Horn JR, et al. Residual gentamicin-release from antibiotic-loaded polymethylmethacrylate beads after 5 years of implantation. *Biomaterials*. 2003;24:1829–1831.
566. Newell SM. Diagnosis and treatment of lymphocytic leukemia and malignant lymphoma in a Pekin duck (*Anas platyrhynchos domesticus*). *J Assoc Avian Vet*. 1991;5:83–86.
567. Nguyen KQ, Hawkins MG, Taylor IT, et al. Stability and uniformity of extemporaneous preparations of voriconazole in two liquid suspension vehicles at two storage temperatures. *Am J Vet Res*. 2009;7:908–914.
568. Nolan PM, Duckworth RA, Hill GE, et al. Maintenance of a captive flock of house finches free of infection by *Mycoplasma gallisepticum*. *Avian Dis*. 2000;44:948–952.
569. Norton TM, Gaskin J, Kollias GV, et al. Efficacy of acyclovir against herpesvirus infection in Quaker parakeets. *Am J Vet Res*. 1991;52:2007–2009.
570. Norton TM, Greiner E, Latimer K, et al. Medical protocols recommended by the U.S. bali mynah SSP. <http://www.riverbanks.org/subsite/aig/new.htm>, 2001.
571. Norton TM, Greiner E, Latimer K, et al. 2004 medical protocols recommended by the U.S. bali mynah SSP. Available at <http://www.riverbanks.org/subsite/aig/new.htm>, Jan 26, 2011. Accessed
572. Norton TM, Neiffer DL, Seibels B, et al. 2007 Atoxoplasma medical protocols recommended by the passerine Atoxoplasma working group. Available

at <http://www.aazv.org/displaycommon.cfm?an=1&subarticlenbr=545>, Jan 26, 2011. Accessed

573. Oaks JL, Gilbert M, Virani MZ, et al. Diclofenac residues as the cause of vulture population decline in Pakistan. *Nature*. 2004;427:630–633.
574. Oglesbee BL. Avian cardiology. *Proc North Am Vet Conf*; 1996:730–731.
575. Oglesbee BL, McDonald S, Warthen K. Avian digestive system disorders. In: Birchard SJ, Sherding RG. *Saunders Manual of Small Animal Practice*. Philadelphia: WB Saunders Co; 1994:1290–1301.
576. Okeson DM, Llizo SY, Miller CL, et al. Antibody response of five bird species after vaccination with a killed West Nile virus vaccine. *J Zoo Wildl Med*. 2007;38:240–244.
577. Olsen GH, Carpenter JW, Langenberg JA. Medicine and surgery. Ellis DH, Gee GF, Mirande CM. *Cranes. Their Biology, Husbandry, and Conservation*. Washington, DC: National Biological Service/International Crane Foundation; 1996:142–143.
578. Olsen GH, Turell MJ, Pagac BB. Efficacy of eastern equine encephalitis immunization in whooping cranes. *J Wildl Dis*. 1997;33:312–315.
579. Olsen GH, Miller KJ, Docherty DE, et al. Pathogenicity of West Nile virus and response to vaccination in sandhill cranes (*Grus canadensis*) using a killed vaccine. *J Zoo Wildl Med*. 2009;40:263–271.
580. Olsen GP, Russell KE, Dierenfeld E, et al. A comparison of four regimens for treatment of iron storage disease using the European starling (*Sturnus vulgaris*) as a model. *J Avian Med Surg*. 2006;20:74–79.
581. Onderka D, Doornenbal E. Mycotic dermatitis in ostriches. *Can Vet J*. 1992;33:72–76.
582. Orcutt CJ, Bartick TE. Mucormycotic meningoencephalitis and pneumonia in a chattering lory (*Lorius garrulus*). *J Assoc Avian Vet*. 1994;8:85–89.

583. Orosz SE, Frazier DL. Antifungal agents. a review of their pharmacology and therapeutic indications. *J Avian Med Surg.* 1995;9:8–18.
584. Orosz SE, Schroeder EC, Frazier DL. Itraconazole. a new antifungal drug for birds. *Proc Annu Conf Assoc Avian Vet;* 1994:13–19.
585. Orosz SE, Schroeder EC, Frazier DL. Pharmacokinetic properties of itraconazole in blue-fronted Amazon parrots (*Amazona aestiva aestiva*). *J Avian Med Surg.* 1996;10:168–173.
586. Orosz SE, Jones MP, Cox SK, et al. Pharmacokinetics of amoxicillin plus clavulanic acid in blue-fronted Amazon parrots (*Amazona aestiva aestiva*). *J Avian Med Surg.* 2000;14:107–112.
587. Orr K. Botulism in a California condor (*Gymnogyps californianus*). *Proc Annu Conf Am Assoc Zoo Vet;* 2002:101–104.
588. Orr KA, Fowler ME. Order Trochiliiformes (hummingbirds). In: Fowler ME, Cubas ZS. *Biology, Medicine, and Surgery of South American Wild Animals.* Ames: Iowa State University Press; 2001:174–179.
589. Overall K. Personal communication; 2011.
590. Ozen H, Karaman M, Ciğremiş Y, et al. Effectiveness of melatonin on aflatoxicosis in chicks. *Res Vet Sci.* 2009;86:485–489.
591. Padilla LR, Miller RE, Flammer K. Doxycycline in drinking water for treatment of *Chlamydophila psittaci* in fruit doves. *Proc Annu Conf Am Assoc Zoo Vet;* 2003:267–268.
592. Page DC, Schmidt RE, English JH, et al. Antemortem diagnosis and treatment of sarcocystosis in two species of psittacines. *J Zoo Wildl Med.* 1992;23:77–85.
593. Paley D, Herzenberg JE. Intramedullary infections treated with antibiotic cement rods. preliminary results in nine cases. *J Orthoped Trauma.* 2002;16:723–729.

594. Papendick R, Stalis I, Harvey C, et al. Suspected fenbendazole toxicity in birds. *Proc Annu Conf Am Assoc Zoo Vet/Am Assoc Wildl Vet*; 1998:144–146.
595. Parrot TY, Cray C, Martin S. Daily dosing of voriconazole and correlation with serological testing. *Proc Annu Conf Assoc Avian Vet*; 2010:69–70.
596. Paul-Murphy J, Ludders JW. Avian analgesia. *Vet Clin North Am Exotic Anim Pract*. 2001;4:35–45.
597. Paul-Murphy JR, Brunson DB, Miletic V. Analgesic effects of butorphanol and buprenorphine in conscious African grey parrots. *Am J Vet Res*. 1999;60:1218–1221.
598. Paul-Murphy J, Hess JC, Fialkowski JP. Pharmacokinetic properties of a single intramuscular dose of buprenorphine in African grey parrots (*Psittacus erithacus erithacus*). *J Avian Med Surg*. 2004;18:224–228.
599. Paul-Murphy JR, Sladky KK, Krugner-Higby LA, et al. Analgesic effects of carprofen and liposome-encapsulated butorphanol tartrate in Hispaniolan parrots (*Amazona ventralis*) with experimentally induced arthritis. *Am J Vet Res*. 2009;70:1201–1210.
600. Pavez JC, Hawkins MG, Pascoe PJ, et al. Effect of fentanyl target-controlled infusions on isoflurane minimum anaesthetic concentration and cardiovascular function in red-tailed hawks (*Buteo jamaicensis*). *Vet Anaesth Analg*. 2011;38:344–351.
601. Pees M, Kuhring K, Demiraij F, et al. Bioavailability and compatibility of enalapril in birds. *Proc Annu Conf Assoc Avian Vet*; 2006:7–11.
602. Pees M, Schmidt V, Coles B, et al. Diagnosis and long-term therapy of right-sided heart failure in a yellow-crowned Amazon (*Amazona ochrocephala*). *Vet Rec*. 2006;158:445–447.
603. Pereira ME, Werther K. Evaluation of the renal effects of flunixin meglumine, ketoprofen and meloxicam in budgerigars (*Melopsittacus undulatus*). *Vet Rec*. 2007;160:844–846.

604. Péricard JM, Andral B. Thiamine deficiency as a possible cause for the “staggers” syndrome of the Griffon vulture (*Gyps fulvus*). *Proc Euro Conf Avian Med Surg*; 1993:191–198.
605. Perpignan D, Melero R. Suspected ivermectin toxicity in a Nanday parakeet (*Nandayus nenday*). *Proc Annu Conf Am Assoc Zoo Vet*; 2003:298–299.
606. Peters TL, Fulton RM, Roberson KD, et al. Effect of antibiotics on in vitro and in vivo avian cartilage degradation. *Avian Dis*. 2002;46:75–86.
607. Phalen DN. Avian renal disorders. In: Fudge AM, ed. *Laboratory Medicine: Avian and Exotic Pets*. Philadelphia: WB Saunders Co; 2000:61–68.
608. Phalen DN. *Diagnosis and treatment of megabacteriosis in birds*. *Vet Quart Rev* (Texas A & M University); 2001; Oct-Dec.
609. Phalen DN. Common bacterial and fungal infectious diseases in pet birds. *Suppl Compend Contin Educ Pract Vet*. 2003;25:43–48.
610. Phalen DN. Implications of viruses in clinical disorders. In: Harrison GJ, Lightfoot TL, eds. *Clinical Avian Medicine*, Vol II. Palm Beach: Spix Publishing; 2006:721–745.
611. Phalen DN. Preventive medicine and screening. In: Harrison GJ, Lightfoot TL, eds. *Clinical Avian Medicine*, Vol II. Palm Beach: Spix Publishing; 2006:573–585.
612. Phalen DN, Logan KS, Snowden KF. Encephalitozoon hellem infection as the cause of a unilateral chronic keratoconjunctivitis in an umbrella cockatoo (*Cacatua alba*). *Vet Ophthalmol*. 2006;9:59–63.
613. Phalen DN, Hays HB, Filippich LJ, et al. Heart failure in a macaw with atherosclerosis of the aorta and brachiocephalic arteries. *J Am Vet Med Assoc*. 1996;209:1435–1440.
614. Plumb DC. *Plumb’s Veterinary Drug Handbook*, 6th ed. Ames: Blackwell Publishing; 2008.

615. Poffers J, Lumeij JT, Redig PT. Investigations into the uricolytic properties of urate oxidase in a granivorous (*Columba livia domestica*) and in a carnivorous (*Buteo jamaicensis*) avian species. *Avian Pathol.* 2002;31:573–579.
616. Poffers J, Lumeij JT, Timmermans-Sprang EPM, et al. Further studies on the use of allopurinol to reduce plasma uric acid concentrations in the red-tailed hawk (*Buteo jamaicensis*) hyperuricaemic model. *Avian Pathol.* 2002;31:567–572.
617. Pollock C. Personal communication; 2003.
618. Pollock CG, Pledger T, Renner M. Diabetes mellitus in avian species. *Proc Annu Conf Assoc Avian Vet*; 2001:151–155.
619. Pollock CG, Schumacher J, Orosz SE, et al. Sedative effects of medetomidine in pigeons. *J Avian Med Surg.* 2001;15:95–100.
620. Polo FJ, Peinado VI, Viscor G, et al. Hematologic and plasma chemistry values in captive psittacine birds. *Avian Dis.* 1998;42:523–535.
621. Ponder J. VIN Avian Boards Web site. Available at [www.vin.com/Members/boards/discussionviewer.aspx?DocumentId54072477](http://www.vin.com/Members/boards/discussionviewer.aspx?DocumentId54072477), Jul 7, 2009. Accessed
622. Porter SL. Vehicular trauma in owls. *Proc Annu Conf Assoc Avian Vet*; 1990:164–170.
623. Porter SL. Euthanasia techniques for wildlife. *Proc North Am Vet Conf*; 1994:925.
624. Potassium bromide handout. [http://www.cvm.tamu.edu/vcpl/publications/Kbr\\_handout.htm](http://www.cvm.tamu.edu/vcpl/publications/Kbr_handout.htm), November 18, 2003. Accessed
625. Powers LV. Interpretation of avian hematologic abnormalities. *Proc Mid-Atlantic States Assoc Avian Vet*; 1997:36–39.
626. Powers LV, Flammer K, Papich M. Preliminary investigation of doxycycline plasma concentrations in cockatiels (*Nymphicus hollandicus*) after administration



by injection or in water or feed. *J Avian Med Surg.* 2000;14:23–30.

627. Powers LV, Pokras M, Rio K, et al. Hematology and occurrence of hemoparasites in migrating sharp-shinned hawks (*Accipiter striatus*) during fall migration. *J Raptor Res.* 1994;28:178–185.

628. Prashar A, Guggenheim JA, Erichsen JT, et al. Measurement of intraocular pressure (IOP) in chickens using a rebound tonometer. quantitative evaluation of variance due to position inaccuracies. *Exp Eye Res.* 2007;85:563–571.

629. Product insert.

630. Prus SE, Clubb SL, Flammer K. Doxycycline plasma concentrations in macaws fed a medicated corn diet. *Avian Dis.* 1992;36:480–483.

631. Quandt JE, Greenacre CB. Sevoflurane anesthesia in psittacines. *J Zoo Wildl Med.* 1999;30:308–309.

632. Quesenberry K. Avian neurologic disorders. In: Birchard SJ, Sherding RG. *Saunders Manual of Small Animal Practice*. 2nd ed. Philadelphia: WB Saunders; 2000:1459–1463.

633. Quesenberry KE. Avian antimicrobial therapeutics. In: Jacobson ER, Kollias GV, Jr. *Exotic Animals*. New York: Churchill Livingstone; 1988:177–207.

634. Quesenberry KE, Hillyer EV. Supportive care and emergency therapy. In: Ritchie BW, Harrison GJ, Harrison LR. *Avian Medicine: Principles and Application*. Lake Worth, FL: Wingers Publ; 1994:382–416.

635. Quintavalla F, Zucca P. Birds of prey. blood chemistry profile for peregrine falcons (*Falco peregrinus*) and eagle owls (*Bubo bubo*) in a raptor centre in north Italy. *Proc Euro Conf Assoc Avian Vet*; 1993:544–551.

636. Raath JP, Quandt SKF, Malan JH. Ostrich (*Struthio camelus*) immobilization using carfentanil and xylazine and reversal with yohimbine and naltrexone. *J South Afr Vet Assoc.* 1992;63:138–140.

637. Radabaugh SC, Lindstrom JG, Dahlhausen B. The use of terbinafine

hydrochloride in the treatment of avian fungal disease. *AAV Clin Forum*; 2007:5–7.

638. Rae M. Endocrine disease in pet birds. *Semin Avian Exotic Pet Med*. 1995;4:32–38.

639. Ramer JC, Paul-Murphy J, Brunson D, et al. Effects of mydriatic agents in cockatoos, African gray parrots, and blue-fronted Amazon parrots. *J Am Vet Med Assoc*. 1996;208:227–230.

640. Ramsay E. Ratite restraint, immobilization, and anesthesia. *Proc Avian Exotic Anim Med Symp*; 1991:176–179.

641. Ramsay E. Personal communication; 2003.

642. Ramsay EC, Grindlinger H. Use of clomipramine in the treatment of obsessive behavior in psittacine birds. *J Assoc Avian Vet*. 1994;8:9.

643. Ramsay EC, Vulliet R. Pharmacokinetic properties of gentamicin and amikacin in the cockatiel. *Avian Dis*. 1993;37:628–634.

644. Ramsay EC, Drew ML, Johnson B. Trichomoniasis in a flock of budgerigars. *Proc Annu Conf Assoc Avian Vet*; 1990:309–311.

645. Randolph K. Equine encephalitis virus in ratites. *Proc Annu Conf Assoc Avian Vet*; 1995:249–252.

646. Rapp JT, Vollmer TR. Stereotypy II. a review of neurobiological interpretations and suggestions for an integration with behavioral methods. *Res Dev Disabil*. 2005;26:548–564.

647. Rathinam T, Chapman HD. Sensitivity of isolates of *Eimeria* from turkey flocks to the anticoccidial drugs amprolium, clopidol, diclazuril, and monensin. *Avian Dis*. 2009;53:405–408.

648. Ratzlaff K, Papich MG, Flammer K. Plasma concentrations of fluconazole after a single oral dose and administration in drinking water in cockatiels (*Nymphicus hollandicus*). *J Avian Med Surg*. 2011;25:23–31.

649. Redig P. Medical Management of Birds of Prey. A Collection of Notes on Selected Topics. St. Paul: The Raptor Center; 1993.
650. Redig P. Recommendations for anesthesia in raptors with comments on trumpeter swans. *Semin Avian Exotic Pet Med*. 1998;7:22–29.
651. Redig P. Infectious diseases; fungal diseases. In: Samour J, ed. *Avian Medicine*. London: Harcourt Publ; 2000:275–291.
652. Redig PT. Fluid therapy and acid-base balance in the critically ill avian patient. *Proc Annu Conf Assoc Avian Vet*; 1984:59–73.
653. Redig PT. Treatment protocol for bumblefoot types 1 and 2. *AAV Today*. 1987;1:207–208.
654. Redig PT. Health management of raptors trained for falconry. *Proc Annu Conf Assoc Avian Vet*; 1992:258–264.
655. Redig PT. Avian emergencies. In: Beynon PH, Forbes NA, Harcourt-Brown NH. *BSAVA Manual of Raptors, Pigeons and Waterfowl*. Ames: Iowa State University Press; 1996:30–41.
656. Redig PT. Nursing avian patients. In: Beynon PH, Forbes NA, Harcourt-Brown NH. *Manual of Raptors, Pigeons and Waterfowl*. Ames: Iowa State University Press; 1996:42–46.
657. Redig PT. Falconiformes (vultures, hawks, falcons, secretary bird). In: Fowler ME, Miller RE. *Zoo and Wild Animal Medicine*. 5th ed. Philadelphia: WB Saunders Co; 2005:150–161.
658. Redig PT, Cruz-Martinez L. Raptors. In: Tully TN, Dorrestein GM, Jones AK. *Avian Medicine*. Edinburgh: Saunders Elsevier; 2009:209–242.
659. Redig PT, Duke GE. Intravenously administered ketamine HCl and diazepam for anesthesia of raptors. *J Am Vet Med Assoc*. 1976;169:886–888.
660. Redig PT, Ponder J. Raptors. practical information every avian practitioner can use. *Proc Annu Conf Assoc of Avian Vet*; 2010:171–180.

661. Redig PT, Talbot B, Guarnera T. Avian malaria. *Proc Annu Conf Assoc Avian Vet*; 1993:173–181.
662. Reidarson TH, McBain JF, Denton D. The use of medroxyprogesterone acetate to induce molting in chinstrap penguins. *J Zoo Wildl Med*. 1999;30:278–280.
663. Reiss AE, Badcock NR. Itraconazole levels in serum, skin and feathers of Gouldian finches (*Chloebia gouldiae*) following in-seed medication. *Proc Joint Conf Am Assoc Zoo Vet/Am Assoc Wildl Vet*; 1998:142–143.
664. Reither NP. Medetomidine and atipamezole in avian practice. *Proc Euro Conf Avian Med Surg*; 1993:43–48.
665. Remple JD. Intracellular hematozoa of raptors. a review and update. *J Avian Med Surg*. 2004;18:75–88.
666. Remple JD, Forbes NA. Antibiotic-impregnated polymethyl methacrylate beads in the treatment of bumblefoot in raptors. In: *Raptor Biomedicine III*. Lake Worth, FL: Zoological Education Network; 2002:255–263.
667. Remple JD, Riddle SK. Pharmacology considerations. *Clinical Avian Med*. 1991;2:77–85.
668. Riggs SM, Hawkins MG, Craigmill AL, et al. Pharmacokinetics of butorphanol tartrate in red-tailed hawks (*Buteo jamaicensis*) and great horned owls (*Bubo virginianus*). *Am J Vet Res*. 2008;69:596–603.
669. Ritchie BW. *Avian Viruses. Function and Control*. Lake Worth, FL: Wingers Publ; 1995.
670. Ritchie BW. Diagnosing and preventing common viral infections in companion birds. *Proc 21st Annu Waltham/OSU Symp*; 1997:7–13.
671. Ritchie BW, Harrison GJ. Formulary. In: Ritchie BW, Harrison GJ, Harrison LR. *Avian Medicine: Principles and Application*. Lake Worth, FL: Wingers Publ; 1994:457–478.

672. Ritchie BW, Harrison GJ. Formulary. In: Ritchie BW, Harrison GJ, Harrison LR. *Avian Medicine: Principles and Application*. Abridged ed. Lake Worth, FL: Wingers Publ; 1997:227–253.
673. Ritchie BW, Harrison GJ, Harrison LR. Hematology and biochemistry. In: Ritchie BW, Harrison GJ, Harrison LR. *Avian Medicine: Principles and Application*. Lake Worth, FL: Wingers Publ; 1994:1331–1347.
674. Ritchie BW, Latimer KS, Leonard J, et al. Safety, immunogenicity and efficacy of an inactivated avian polyomavirus vaccine. *Am J Vet Res*. 1998;59:143–148.
675. Ritchie BW, Vaughn SB, St. Leger J, et al. Use of an inactivated virus vaccine to control polyomavirus outbreaks in nine flocks of psittacine birds. *J Am Vet Med Assoc*. 1998;212:685–690.
676. Rivera S, McClearen J, Reavill DR. Suspected fenbendazole toxicity in pigeons (*Columba livia*). *Proc Annu Conf Assoc Avian Vet*; 2000:207–209.
677. Rivera S, McClearen JR, Reavill DR. Treatment of nonepitheliotropic cutaneous B-cell lymphoma in an umbrella cockatoo (*Cacatua alba*). *J Avian Med Surg*. 2009;23:294–302.
678. Robbins PK, Tell LA, Needham ML, et al. Pharmacokinetics of piperacillin after intramuscular injection in red-tailed hawks and great horned owls. *J Zoo Wildl Med*. 2000;31:47–51.
679. Roberts MF. *Pigeons*. Jersey City: TFH Publ; 1962.
680. Rochette F, Engelen M, Bossche HV. Antifungal agents of use in animals health—practical applications. *J Vet Pharmacol*. 2003;26:31–53.
681. Rolinski Z, Kowalski C, Wlaz P. Distribution and elimination of norfloxacin from broiler chicken tissues and eggs. *J Vet Pharmacol Therap*. 1997;20:200–201.
682. Romagnano A. Magnetic resonance imaging of the avian brain and abdominal cavity. *Proc Annu Conf Assoc Avian Vet*; 1995:307–309.

683. Romagnano A. Avian obstetrics. *Semin Avian Exotic Pet Med*. 1996;5:180–188.
684. Romagnano A. Examination and preventive medicine protocols in psittacines. *Vet Clin North Am Exotic Anim Pract*. 1999;2:333–355.
685. Rosenthal K. Psychotropic agents in pet birds. *Proc North Am Vet Conf*; 2000:920–921.
686. Rosenthal KL, Johnston M. Hypothyroidism in a red-lored Amazon (*Amazona autumnalis*). *Proc Annu Conf Assoc Avian Vet*; 2003:33–36.
687. Rosenthal K, Stamoulis M. Diagnosis of congestive heart failure in an Indian Hill mynah bird (*Gracula religiosa*). *J Assoc Avian Vet*. 1993;7:27–30.
688. Rosenthal K, Duda L, Ivey ES, et al. A report of photodynamic therapy for squamous cell carcinoma in a cockatiel. *Proc Annu Conf Assoc Avian Vet*; 2001:175–176.
689. Rosskopf WJ, Woerpel RW. Practical avian therapeutics with dosages of commonly used medications. (Sydney, Australia): *Proc Basics Avian Med*; 1996:75–81.
690. Rupiper DJ. IME—Allopurinol in simple syrup for gout. *J Assoc Avian Vet*. 1993;7:219.
691. Rupiper DJ. Diseases that affect race performance of homing pigeons. Part 1. Husbandry, diagnostic strategies, and viral diseases. *J Avian Med Surg*. 1998;12:70–77.
692. Rupiper DJ. Personal communication; 2004.
693. Rupiper DJ, Ehrenberg M. Introduction to pigeon practice. *Proc Annu Conf Assoc Avian Vet*; 1994:203–211.
694. Rupiper DJ, Ehrenberg M. Practical pigeon medicine. *Proc Annu Conf Assoc Avian Vet*; 1997:479–497.

695. Rupley AE. Respiratory bacterial, fungal and parasitic diseases. *Proc Avian Specialty Advanced Prog Small Mam Rept Med Surg (Annu Conf Assoc Avian Vet)*; 1997:23–44.
696. Rupley AE. Critical care of pet birds. *Vet Clin North Am Exotic Anim Pract*. 1998;1:11–41.
697. Rush EM, Hunter RP, Papich M, et al. Pharmacokinetics and safety of acyclovir in tragopans (Tragopan species). *J Avian Med Surg*. 2005;19:271–276.
698. Russell AD, Hugo WB, Ayliffe GAJ. *Principles and Practice of Disinfection, Preservation and Sterilization*, 3rd ed. Malden, MA: Blackwell Science; 1999.
699. Sabrautzki S. The course of gentamicin concentrations in serum and tissues of pigeons. Inaugural dissertation. Tierärztliche Fakultät der Ludwig-Maximilians-Universität München. *Vet Bull*. 1983;54:5915.
700. Sacre B, Oppenheim Y, Steinberg H, et al. Presumptive histiocytic sarcoma in a great horned owl. *J Zoo Wildl Med*. 1992;23:113–121.
701. Saggese MD, Tizard I, Phalen DN. Efficacy of multi-drug therapy with azithromycin, rifampin, and ethambutol for the treatment of ring-necked doves (*Streptopelia risoria*) naturally infected with avian mycobacteriosis. *Proc Annu Conf Assoc Avian Vet*; 2007:27–29.
702. Samour J. Pharmaceuticals commonly used in avian medicine. In: Samour J, ed. *Avian Medicine*. Philadelphia: Mosby; 2000:388–418.
703. Samour J. Toxicology. In: Samour J, ed. *Avian Medicine*. London: Mosby; 2000:180–193.
704. Samour J. Management of raptors. In: Harrison GJ, Lightfoot TL, eds. *Clinical Avian Medicine*, Vol II. Palm Beach: Spix Publishing; 2006:948–954.
705. Samour JH, Naldo J. Serratospiculiasis in captive falcons in the Middle East. a review. *J Avian Med Surg*. 2001;15:2–9.
706. Samour JH, Naldo J. Diagnosis and therapeutic management of lead toxicosis

in falcons in Saudi Arabia. *J Avian Med Surg*. 2002;16:16–20.

707. Samour JH, Naldo J. Diagnosis and therapeutic management of trichomoniasis in falcons in Saudi Arabia. *J Avian Med Surg*. 2003;17:135–143.

708. Samour JH, Irwin-Davies J, Faraj E. Chemical immobilisation in ostriches using etorphine hydrochloride. *Vet Rec*. 1990;127:575–576.

709. Samour JH, Naldo JL, John SK. Therapeutic management of *Babesia shortii* infection in a peregrine falcon (*Falco peregrinus*). *J Avian Med Surg*. 2005;19:294–296.

710. Samour JH, Jones DM, Knight JA, et al. Comparative studies of the use of some injectable anesthetic agents in birds. *Vet Rec*. 1984;115:6–11.

711. Sanchez-Migallon GD, Paul-Murphy J, Barker S, et al. Plasma concentrations of butorphanol in Hispaniolan Amazon parrots (*Amazona ventralis*) after intravenous and oral administration. *Proc Annu Conf Assoc Avian Vet/Assoc Exotic Mam Vet*; 2008:23–24.

712. Sanchez-Migallon Guzman D, Flammer K, Paul-Murphy J, et al. Pharmacokinetics of butorphanol after oral, intravenous and intramuscular administration in Hispaniolan Amazon parrots (*Amazona ventralis*). *J Avian Med Surg*. 2011;25:185–191.

713. Sanchez-Migallon Guzman D, Kukanich B, Keuler NS, et al. Antinociceptive effects of nalbuphine hydrochloride in Hispaniolan Amazon parrots (*Amazona ventralis*). *Am J Vet Res*. 2011;72:736–740.

714. Sandmeier P. Evaluation of medetomidine for short-term immobilization of domestic pigeons (*Columba livia*) and Amazon parrots (*Amazona* species). *J Avian Med Surg*. 2000;14:8–14.

715. Santangelo B, Ferrari D, Di Martino I, et al. Dexmedetomidine chemical restraint in two raptor species undergoing inhalation anaesthesia. *Vet Res Commun*. 2009;33:S209–S211.

716. Sarkozy G, Semjen G, Laczay P, et al. Treatment of experimentally induced



*Pasteurella multocida* in broilers and turkeys. comparative studies of different oral treatment regimens. *J Vet Med B Infect Dis Vet Public Health*. 2002;49:130–134.

717. Schaeffer DO. Avian euthanasia. *Proc Annu Conf Assoc Avian Vet*; 1996:287–288.

718. Schink B, Korbel RT. Investigations on pharmacokinetics and pharmacodynamics of cefovecin in domestic pigeons. *Proc Annu Conf Assoc Avian Vet*; 2010:301–302.

719. Schmidt EMS, Paulillo AC, Dittrich RL, et al. Serum biochemical parameters in the ring-necked pheasant (*Phasianus colchius*) on breeding season. *Int J Poult Sci*. 2007;6:673–674.

720. Schmidt V, Demiraj F, Di Somma A, et al. Plasma concentrations of voriconazole in falcons. *Vet Rec*. 2007;161:265–268.

721. Schnellbacher RW, DaCuhna A, Beaufriere H, et al. The effects of adrenergic agonists as a treatment for isoflurane-induced hypotension in Hispaniolan Amazon parrots (*Amazona ventralis*). *Proc Annu Conf Assoc Avian Vet/Assoc Exotic Mam Vet*; 2010:285.

722. Schobert E. Telazol® use in wild and exotic animals. *Vet Med*; 1987:1080–1088. (Oct)

723. Scholtz N, Halle I, Flachowsky G, et al. Serum chemistry reference values in adult Japanese quail (*Coturnix coturnix japonica*) including sex-related differences. *Poult Sci*. 2009;88:1186–1190.

724. Schroeder EC, Frazier DL, Morris PJ, et al. Pharmacokinetics of ticarcillin and amikacin in blue-fronted Amazon parrots (*Amazona aestiva aestiva*). *J Avian Med Surg*. 1997;11:260–267.

725. Schuetz S, Krautwald-Junghanns ME, Lutz F, et al. Pharmacokinetic and clinical studies of the carbapenem antibiotic, meropenem, in birds. *Proc Annu Conf Assoc Avian Vet*; 2001:183–190.

726. Schumacher J, Citino SB, Hernandez K, et al. Cardiopulmonary and

- anesthetic effects of propofol in wild turkeys. *Am J Vet Res*. 1997;58:1014–1017.
727. Scope A, Schwendenwein I, Enders F, et al. Hematologic and clinical chemistry reference values in red lories. *Avian Dis*. 2000;44:885–890.
728. Sedgwick CJ. Anesthesia of caged birds. In: Kirk RW, ed. *Current Veterinary Therapy VII: Small Animal Practice*. Philadelphia: WB Saunders Co; 1980:653–656.
729. Seibels B, Lamberski N, Gregory CR, et al. Effective use of tea to limit dietary iron available to starlings (*Sturnus vulgaris*). *J Zoo Wildl Med*. 2003;34:314–316.
730. Seibert LM. *Psittacine feather picking*. Proc West Vet Conf; 2003.
731. Seibert LM, Tobias K, Sequin B. Understanding behavior. husbandry considerations for better behavioral health in psittacine species. *Compend Contin Educ Vet*. 2007;29:303–306.
732. Seibert LM, Crowell-Davis SL, Wilson GH, et al. Placebo-controlled clomipramine trial for the treatment of feather picking disorder in cockatoos. *J Am Anim Hosp Assoc*. 2004;40:261–269.
733. Sellers C. Personal communication; 2003.
734. Shaver SL, Robinson NG, Wright BD, et al. A multimodal approach to management of suspected neuropathic pain in a prairie falcon (*Falco mexicanus*). *J Avian Med Surg*. 2009;23:209–213.
735. Sibley DA. *The Sibley Guide to Birds*. New York: Knopf; 2000.
736. Siegal-Willot JL, Carpenter JW, Glaser AL. Lack of detectable antibody response in greater flamingos (*Phoenicopterus ruber ruber*) after vaccination against West Nile Virus with a killed equine vaccine. *J Avian Med Surg*. 2006;20:89–93.
737. Silveira LF, Hofling E, Moro MEG. Order Tinamiformes (tinamous). In: Fowler ME, Cubas ZS, et al. *Biology, Medicine, and Surgery of South American Wild Animals*. Ames: Iowa State University Press; 2001:72–80.

738. Simone-Freilicher E. Use of isoxsuprine for treatment of clinical signs associated with presumptive atherosclerosis in a yellow-naped Amazon parrot (*Amazona ochrocephala auropalliata*). *J Avian Med Surg*. 2007;21:215–219.
739. Simpson BS, Papich MG. Pharmacologic management in veterinary behavioral medicine. *Vet Clin North Am Small Anim Pract*. 2003;33:365–404.
740. Sinclair K, Paul-Murphy J, Church M, et al. Renal physiologic and histopathologic effects of meloxicam in Japanese quail (*Coturnix japonica*). *Proc Annu Conf Assoc Avian Vet/Assoc Exotic Mam Vet*; 2010:287–288.
741. Sinn LC. Anesthesiology. In: Ritchie BW, Harrison GJ, Harrison LR. *Avian Medicine: Principles and Application*. Lake Worth, FL: Wingers Publ; 1994:1066–1080.
742. Siperstein LJ. Use of neurontin (gabapentin) to treat leg twitching/foot mutilation in a Senegal parrot. *Proc Annu Conf Assoc Avian Vet/Assoc Exotic Mam Vet*; 2007:335.
743. Skallerup P, Luna LA, Johansen MV, et al. The impact of natural helminth infections and supplementary protein on growth performance of free-range chickens on smallholder farms in El Sauce, Nicaragua. *Prev Vet Med*. 2005;69:229–244.
744. Sladky KK, Krugner-Higby L, Meek-Walker E, et al. Serum concentrations and analgesic effects of liposome-encapsulated and standard butorphanol tartrate in parrots. *Am J Vet Res*. 2006;67:775–781.
745. Smith JA, Tully TN, Cornick JL. Determination of isoflurane minimum anesthetic concentration in emus. *Proc Annu Conf Assoc Avian Vet*; 1997:181–182.
746. Smith SA. Diagnosis and treatment of helminths in birds of prey. In: Redig PT, Cooper JE, Remple JD, et al. *Raptor Biomedicine*. Minneapolis: University of Minnesota Press; 1993:21–27.
747. Smith SA. Parasites of birds of prey. their diagnosis and treatment. *Semin Avian Exotic Pet Med*. 1996;5:97–105.

748. Snowden K, Phalen DN. Encephalitozoon infection in birds. *Semin Avian Exotic Pet Med*. 2004;13:94–99.
749. Snyder SB, Richard MJ. Treatment of avian tuberculosis in a whooping crane (*Grus americana*). *Proc Annu Conf Am Assoc Zoo Vet*; 1994:167–170.
750. Soenens J, Vermeersch H, Baert K, et al. Pharmacokinetics and efficacy of amoxicillin in the treatment of an experimental *Streptococcus bovis* infection in racing pigeons (*Columba livia*). *Vet J*. 1998;156:59–65.
751. Souza MJ, Cox SK. Tramadol use in zoologic medicine. *Vet Clin North Am Exotic Anim Pract*. 2011;14:117–130.
752. Souza MJ, Martin-Jimenez T, Jones MP, et al. Pharmacokinetics of intravenous and oral tramadol in the bald eagle (*Haliaeetus leucocephalus*). *J Avian Med Surg*. 2009;23:247–252.
753. Souza MJ, Martin-Jimenez T, Jones MP, et al. Pharmacokinetics of oral tramadol in red-tailed hawks (*Buteo jamaicensis*). *J Vet Pharmacol Ther*. 2010;34:86–88.
754. Souza MJ, Sanchez-Migallon GD, Paul-Murphy J, et al. Tramadol in Hispaniolan Amazon parrots (*Amazona ventralis*). *Proc Annu Conf Assoc Avian Vet/Assoc Exotic Mam Vet*; 2010:293–294.
755. Speer BL. Laying problems in caged birds. In: Bongaura JD, ed. *Kirk's Current Veterinary Therapy XIII*. Philadelphia: WB Saunders Co; 2000:1110–1113.
756. Sreter T, Szell Z, Varga I. Anticryptosporidial prophylactic efficacy of enrofloxacin and paromomycin in chickens. *J Parasitol*. 2002;88:209–211.
757. Stadler C, Carpenter JW. Parasites of backyard game birds. *Semin Avian Exotic Pet Med*. 1996;5:85–96.
758. Stake PE. Taxomifen induced forced-rest/molt in laying hens. *Poult Sci*. 1979;58:1111.

759. Stalis IH, Rideout BA, Allen JL, et al. Possible albendazole toxicity in birds. *Proc Joint Conf Am Assoc Zoo Vet/Wildl Dis Assoc/Am Assoc Wildl Vet*; 1995:190–191.
760. Stanford M. Cage and aviary birds. In: Meredith A, Redrobe S. *BSAVA Manual of Exotic Pets*. 4th ed. Gloucester, GB: British Small Animal Veterinary Association; 2002:157–167.
761. Stanford M. Use of Doxirobe Gel®. *Exotic DVM*. 2002;4:11.
762. Stanford M. Interferon treatment of circovirus infection in grey parrots (*Psittacus erithacus*). *Vet Rec*. 2004;154:435–436.
763. Stanley T. New developments in opioid drug research for alleviation of animal pain. *J Am Vet Med Assoc*. 1987;191:1252–1253.
764. Starkey SR, Morrissey JK, Hickam JD, et al. Extrapyramidal side effects in a blue and gold macaw (*Ara ararauna*) treated with haloperidol and clomipramine. *J Avian Med Surg*. 2008;22:234–239.
765. Stegemann M. Comparative pharmacokinetic studies of pulse and continuous dosing. *Euro Poult Symp*; 1995:37–41.
766. Steinhort LA. Avian fluid therapy. *J Avian Med Surg*. 1999;13:83–91.
767. Steinhort LA. Diagnosis and treatment of common diseases of finches. In: Bongaura JD, ed. *Kirk's Current Veterinary Therapy XIII*. Philadelphia: WB Saunders Co; 2000:1119–1123.
768. Stern H, Gratzek A, Reavill D. Successful treatment of keratomycosis caused by *Candida* in a peach-faced lovebird (*Agapornis roseicollis*). *Proc Annu Conf Assoc Avian Vet*; 2010:377–378.
769. Stetter MD, Sheppard C, Cook RA. Itraconazole-impregnated synthetic grit for sustained release dosing in avian species. *Proc Annu Conf Am Assoc Zoo Vet*; 1996:181–185.
770. Stewart JS. IME—Restraint and anesthesia of ratites. *J Assoc Avian Vet*.

1990;4:90.

771. Stiles J, Buyukmihci NC, Farver TB. Tonometry of normal eyes in raptors. *Am J Vet Res*. 1994;55:477–479.

772. Stipkovits L, Burch DGS, Salyi G, et al. Study to test the compatibility of Tetramutin® given in feed at different levels with salinomycin (60 ppm) in chickens. *J Vet Pharmacol Therap*. 1997;20:191–192.

773. St. Leger J, Read DH, Shivaprasad HL. Passerine protozoal sinusitis. an infection you should know about. *Proc Annu Conf Assoc Avian Vet*; 1998:157–160.

774. Stone EG. Preliminary evaluation of hetastarch for the management of hypoproteinemia and hypovolemia. *Proc Annu Conf Assoc Avian Vet*; 1994:197–199.

775. Stunkard JA. *Diagnostics, Treatment and Husbandry of Pet Birds*. Edgewater, MD: Stunkard Publ Co; 1984.

776. Suarez DL. Appetite stimulation in raptors. In: Redig PT, Cooper JE, Remple DJ, et al. *Raptor Biomedicine*. Minneapolis: University of Minnesota Press; 1993:225–228.

777. Suedmeyer WK. IME—Use of Adequan in articular diseases of avian species. *J Assoc Avian Vet*. 1993;7:105.

778. Suedmeyer WK, McMurtry D. Use of 9,10 anthraquinone, flight control, to deter Canada geese (*Branta canadensis*) from zoo grounds. *Proc Joint Conf Am Assoc Zoo Vet/Internat Assoc Aquatic Anim Med*; 2000:369–370.

779. Suedmeyer WK, Bermudez A, Fales W. Treatment of epidermal cysts associated with *Aspergillus fumigatus* and an *Alternaria* sp. in a silky bantam chicken (*Gallus gallus*). *Proc Joint Conf Am Assoc Zoo Vet/Internat Assoc Aquatic Anim Med*; 2000:307–309.

780. Suedmeyer WK, Haynes N, Roberts D. Clinical management of endoventricular mycoses in a group of African finches. *Proc Annu Conf Assoc*

Avian Vet; 1997:225–227.

781. Suedmeyer WK, McCaw D, Turnquist S. Use of photodynamic therapy against squamous cell carcinoma in the casque of a great Indian hornbill (*Buceros bicornis*). *Proc Annu Conf Am Assoc Zoo Vet*; 1999:283–285.

782. Swalec-Tobias KM, Schneider RK, Besser TE. Use of antimicrobial-impregnated polymethyl methacrylate. *J Am Vet Med Assoc*. 1996;208:841–845.

783. Swan GE, Cuthbert R, Quevedo M, et al. Toxicity of diclofenac to Gyps vultures. *Biol Lett*. 2006;2:279–282.

784. Swarup D, Patra RC, Prakash V, et al. Safety of meloxicam to critically endangered Gyps vultures and other scavenging birds in India. *Anim Cons*. 2007;10:192–198.

785. Swinnerton KJ, Greenwood AG, Chapman RE, et al. The incidence of the parasitic disease trichomoniasis and its treatment in reintroduced and wild pink pigeons *Columba mayeri*. *Ibis*. 2005;147:772–782.

786. Szelenyi Z, Peczely P. Thyroxine induced moult in domestic hen. *Acta Physiol Hung*. 1988;72:143–149.

787. Tanner AC. Antimicrobial drug use in poultry. In: Prescott J, Baggot J. *Antimicrobial Therapy in Veterinary Medicine*. 3rd ed. Ames: Iowa State University Press; 2000:637–655.

788. Tanner AC, Avakian AP, Barnes HJ, et al. A comparison of danofloxacin and tylosin in the control of induced *Mycoplasma gallisepticum* infection in broiler chicks. *Avian Dis*. 1993;37:515–522.

789. Tarello W. Serratospiculosis in falcons from Kuwait. incidence, pathogenicity and treatment with melarsomine and ivermectin. *Parasite*. 2006;13:59–63.

790. Tarello W. Clinical signs and response to primaquine in falcons with *Haemoproteus tinnunculi* infection. *Vet Rec*. 2007;161:204–206.

791. Tarello W. Efficacy of ivermectin (Ivomec) against intestinal capillariosis in falcons. *Parasite*. 2008;15:171–174.
792. Tavernier P, Saggese M, Van Wettere A, et al. Malaria in an eastern screech owl (*Megascops asio*). *Avian Dis*. 2005;9:433–435.
793. Taylor SM, Kenny J, Houston A, et al. Efficacy, pharmacokinetics and effect on egg-laying and hatchability of two dose rates of in-feed fenbendazole for the treatment of *Capillaria* species infections in chickens. *Vet Rec*. 1993;133:519–521.
794. Teare JA. Antagonism of xylazine hydrochloride-ketamine hydrochloride immobilization in guineafowl (*Numidia meleagris*) by yohimbine hydrochloride. *J Wildl Dis*. 1987;23:301–305.
795. Teare JA, Schwark WS, Shin SJ, et al. Pharmacokinetics of a long-acting oxytetracycline preparation in ring-necked pheasants, great horned owls and Amazon parrots. *Am J Vet Res*. 1985;46:2639–2643.
796. Tell L, Harrenstien L, Wetzlich S, et al. Pharmacokinetics of ceftiofur sodium in exotic and domestic avian species. *J Vet Pharmacol Therap*. 1998;21:85–91.
797. Tell L, Shukla A, Munson L, et al. A comparison of the effects of slow release, injectable levonorgestrel and depot medroxyprogesterone acetate on egg production in Japanese quail (*Coturnix coturnix japonica*). *J Avian Med Surg*. 1999;13:23–31.
798. Tell LA, Clemons KV, Kline Y, et al. Efficacy of voriconazole in Japanese quail (*Coturnix japonica*) experimentally infected with *Aspergillus fumigatus*. *Med Mycol*. 2010;48:234–244.
799. Tell LA, Craigmill AL, Clemons KV, et al. Studies on itraconazole delivery and pharmacokinetics in mallard ducks (*Anas platyrhynchos*). *J Vet Pharmacol Therap*. 2005;28:267–274.
800. Tengelsen LA, Bowen RA, Royals MA, et al. Response to and efficacy of vaccination against eastern equine encephalomyelitis virus in emus. *J Am Vet Med Assoc*. 2001;218:1469–1473.



801. Tennant B. *Small Animal Formulary*. Mid Glamorgan, Wales, UK: Stephens & George Ltd; 1994.
802. Ter Beest J, McClean M, Cushing A, et al. Efficacy of thiofentanil-dexmedetomidine-Telazol for greater rhea (*Rhea americana*) immobilizations. *Proc Joint Conf Am Assoc Zoo Vet/Am Assoc Wildl Vet*; 2010:202.
803. Thomas-Baker B, Dew RD, Patton S. Ivermectin treatment of ocular nematodiasis in birds. *J Am Vet Med Assoc*. 1986;189:1113.
804. Thuesen LR, Bertelsen MF, Brimer L, et al. Selected pharmacokinetic parameters for ceftiofur in hens and green iguanas. *J Vet Pharmacol Ther*. 2009;32:613–617.
805. Touzout-Jourde G, Hernandez-Divers SJ, Trim CM, et al. Cardiopulmonary effects of controlled versus spontaneous ventilation in pigeons anesthetized for coelioscopy. *J Am Vet Med Assoc*. 2005;227:1424–1428.
806. Tseng FS. Considerations in care for birds affected by oil spills. *Semin Avian Exotic Pet Med*. 1999;8:21–31.
807. Tsiquaye KN, Slomka MJ, Maung M. Oral famciclovir against duck hepatitis B virus replication in hepatic and nonhepatic tissues of ducklings infected in ovo. *J Med Virol*. 1994;42:306–310.
808. Tudor DC. *Pigeon Health and Disease*. Ames: Iowa State University Press; 1991.
809. Tully TN. A treatment protocol for non-responsive arthritis in companion birds. *Proc Annu Conf Assoc Avian Vet*; 1994:45–49.
810. Tully TN. Therapeutics. In: Tully TN, Shane SM. *Ratite Management, Medicine, and Surgery*. Malabar, FL: Krieger Publ; 1996:155–163.
811. Tully TN. Formulary. In: Altman RB, Clubb SL, Dorrestein GM, et al. *Avian Medicine and Surgery*. Philadelphia: WB Saunders Co; 1997:671–688.
812. Tully TN. Psittacine therapeutics. *Vet Clin North Am Exotic Anim Pract*.

2000;3:59–90.

813. Tully TN. Personal communication; 2003.

814. Tully TN, Jr. Birds. In: Mitchell MA, Tully TN, Jr. *Manual of Exotic Pet Practice*. St. Louis: Saunders/Elsevier; 2009:250–298.

815. Turbahn A, De Jäckel SC, Greuel E, et al. Dose response study of enrofloxacin against *Riemerella anatipestifer* septicaemia in muscovy and Pekin ducklings. *Avian Pathol*. 1997;26:791–802.

816. Turner R. Trexan (naltrexone hydrochloride) use in feather picking in avian species. *Proc Annu Conf Assoc Avian Vet*; 1993:116–118.

817. Ueblacker SN. Trichomoniasis in American kestrels (*Falco sparverius*) and Eastern screech-owls (*Otus asio*). In: Lumeij JT, Remple JD, Redig PT, et al. *Raptor Biomedicine III*. Lake Worth, FL: Zoological Education Network; 2000:59–63.

818. University of Miami School of Medicine, Comparative Pathology Laboratory, Miami, FL

819. Uzun M, Onder F, Atalan G, et al. Effects of xylazine, medetomidine, detomidine, and diazepam on sedation, heart and respiratory rates, and cloacal temperature in rock partridges (*Alectoris graeca*). *J Zoo Wildl Med*. 2006;37:135–140.

820. Valverde A, Bienzle D, Smith DA, et al. Intraosseous cannulation and drug administration for induction of anesthesia in chickens. *Vet Surg*. 1993;22:240–244.

821. Valverde A, Honeyman VL, Dyson DH, et al. Determination of a sedative dose and influence of midazolam on cardiopulmonary function in Canada geese. *Am J Vet Res*. 1990;51:1071–1074.

822. Van Alstine WG, Dyer DC. Antibiotic aerosolization. tissue and plasma oxytetracycline concentrations in turkey poults. *Avian Dis*. 1985;29:430–436.

823. VanDerHeyden N. Update on avian mycobacteriosis. *Proc Annu Conf Assoc Avian Vet*; 1994:53–61.
824. VanDerHeyden N. New strategies in the treatment of avian mycobacteriosis. *Semin Avian Exotic Pet Med*. 1997;6:25–33.
825. Vanhaecke E, De Backer P, Remon JP, et al. Pharmacokinetics and bioavailability of erythromycin in pigeons (*Columba livia*). *J Vet Pharmacol Ther*. 1990;13:356–360.
826. Van Heerden J, Keffen R. Preliminary investigation into the immobilizing of ostriches. *J South Afr Vet Assoc*. 1991;62:114–117.
827. van Raaij TM, Visser LE, Vulto AG, et al. Acute renal failure after local gentamicin treatment in an infected total knee arthroplasty. *J Arthroplasty*. 2002;17:948–950.
828. Van Sant F. Zinc and clinical disease in parrots. *Proc Annu Conf Assoc Avian Vet*; 1997:387–391.
829. Van Sant F, Steswart GR. Ponazuril used as a treatment for suspected *Cryptosporidium* infection in 2 hybrid falcons. *Proc Annu Conf Assoc Avian Vet*; 2009:368–371.
830. Vercruysse J. Efficacy of toltrazuril and clazuril against experimental infections with *Eimeria labbeana* and *E. columbarum* in racing pigeons. *Avian Dis*. 1990;34:73–79.
831. Vereecken M, DeHerdt P, Ducatelle R, et al. The effect of vaccination on the course of an experimental *Salmonella typhimurium* infection in racing pigeons. *Avian Pathol*. 2000;29:465–471.
832. Vesal N, Eskandari MH. Sedative effects of midazolam and xylazine with or without ketamine and detomidine alone following intranasal administration in ring-necked parakeets. *J Am Vet Med Assoc*. 2006;228:383–388.
833. Vesal N, Zare P. Clinical evaluation of intranasal benzodiazepines, alpha-agonists and their antagonists in canaries. *Vet Anaesth Analg*. 2006;33:143–148.

834. Villanua D, Acevedo P, Hofle U, et al. Changes in parasite transmission stage excretion after pheasant release. *J Helminthol*. 2006;80:313–318.
835. Vink-Nooteboom M, Lumeij JT, Wolvekamp WT. Radiography and image-intensified fluoroscopy of barium passage through the gastrointestinal tract in six healthy Amazon parrots (*Amazona aestiva*). *Vet Radiol Ultrasound*. 2003;44:43–48.
836. Vogel L, Gerlach H, Loffler M. Columbiformes. In: Ritchie BW, Harrison GJ, Harrison LR. *Avian Medicine: Principles and Application*. Lake Worth, FL: Wingers Publ; 1994:1200–1217.
837. Vriends MM. *Simon & Schuster's Guide to Pet Birds*. New York: Simon & Schuster; 1984.
838. Wagner CH, Hochleitner M, Rausch W-D. Ketoconazole plasma levels in buzzards. *Proc First Conf Euro Comm Assoc Avian Vet*; 1991:333–340.
839. Weber MA, Terrell SP, Neiffer DL, et al. Bone marrow hypoplasia and intestinal crypt cell necrosis associated with fenbendazole administration in five painted storks. *J Am Vet Med Assoc*. 2002;221:417–419.
840. Welle KR. A review of psychotropic drug therapy. *Proc Annu Conf Assoc Avian Vet*; 1998:121–124.
841. Welsh RD, Nieman RW, Vanhooser SL, et al. Bacterial infections in ratites. *Vet Med*. 1997;92:992–998.
842. Westerhof I. Ocular filariasis in a parakeet, a tropical surprise. *Tijdschrift voor Diergeneeskunde*. 1992;117:38S. (Suppl)
843. Weston HS. The successful treatment of sarcocystosis in two keas (*Nestor nobilis*) at the Franklin Park Zoo. *Proc Annu Conf Am Assoc Zoo Vet*; 1996:186–191.
844. Wheler C. Avian anesthetics, analgesics, tranquilizers. *Semin Avian Exotic Pet Med*. 1993;2:7–12.

845. Wheler CL, Machin KL, Lew LJ. Use of antibiotic-impregnated polymethylmethacrylate beads in the treatment of chronic osteomyelitis and cellulitis in a juvenile bald eagle (*Haliaeetus leucocephalus*). *Proc Annu Conf Assoc Avian Vet*; 1996:187–194.
846. White J. Neotropical songbirds and veterinary medicine. are we giving them the attention they deserve. *Proc Annu Conf Assoc Avian Vet*; 1997:77–82.
847. Whiteside DP, Barker IK, Conlon PD, et al. Pharmacokinetic disposition of the oral iron chelator deferiprone in the white leghorn chicken. *J Avian Med Surg*. 2007;21:110–120.
848. Whiteside DP, Barker IK, Mehren KG, et al. Evaluation of the oral iron chelator deferiprone for the treatment of iron overload in avian species. *Proc Annu Conf Am Assoc Zoo Vet/Am Assoc Wildl Vet/Assoc Rept Amph Vet/Nat Assoc Zoo Wildl Vet*; 2001:215–219.
849. Wigle WL. Respiratory diseases of gallinaceous birds. *Vet Clin North Am Exotic Anim Pract*. 2000;3:403–421.
850. Willette M, Ponder J, Cruz-Martinez L, et al. Management of select bacterial and parasitic conditions of raptors. *Vet Clin North Am Exotic Anim Pract*. 2009;12:491–517.
851. Williams M, Smith PJ, Loerzel SM, et al. Evaluation of the efficacy of vecuronium bromide as a mydriatic in several different species of aquatic birds. *Proc Annu Conf Assoc Avian Vet*; 1996:113–117.
852. Williams SM, Fulton RM, Render JA, et al. Ocular and encephalic toxoplasmosis in canaries. *Avian Dis*. 2001;45:262–267.
853. Wilson GH, Greenacre CB, Howerth EW, et al. Ascariidosis in a group of psittacine birds. *J Avian Med Surg*. 1999;13:32–39.
854. Wilson GH, Hernandez-Divers S, Budsberg SC, et al. Pharmacokinetics and use of meloxicam in psittacine birds. *Proc Annu Conf Assoc Avian Vet*; 2004:7–9.

855. Wilson H. Avian emergency and critical care. *Proc Annu Conf Assoc Avian Vet*; 2003:261–267.
856. Wilson H, Seibert L, Ritchie BW. Clomipramine trial in feather picking cockatoos. Part I. *Proc Annu Conf Assoc Avian Vet*; 2002:35–37.
857. Wilson H, Graham J, Roberts R, et al. Integumentary neoplasms in psittacine birds. treatment strategies. *Proc Annu Conf Assoc Avian Vet*; 2000:211–214.
858. Wilson RC, Zenoble RD, Horton CR, Jr., et al. Single dose digoxin pharmacokinetics in the quaker conure (*Myiopsitta monachus*). *J Zoo Wildl Med*. 1989;20:432–434.
859. Wobeser GA. *Diseases of Wild Waterfowl*. New York: Plenum Press; 1997.
860. Woerpel RW, Roskopf WJ, Jr. Clinical experience with avian laboratory diagnostics. *Vet Clin North Am Small Anim Pract*. 1984;14:249–286.
861. Woolcock PR. Duck hepatitis virus type I. studies with inactivated vaccines in breeder ducks. *Avian Pathol*. 1991;20:509–522.
862. Worell AB. Therapy of noninfectious avian disorders. *Semin Avian Exotic Pet Med*. 1993;2:42–47.
863. Worell AB. Toucans and mynahs. In: Altman RB, Clubb SL, Dorrestein GM, et al. *Avian Medicine and Surgery*. Philadelphia: WB Saunders Co; 1997:910–917.
864. Yadav S, Srivastav AK. Influence of calcitonin administration on ultimobranchial and parathyroid glands of pigeon, *Columba livia*. *Microsc Res Tech*. 2009;72:380–384.
865. Yuan L, Sun J, Wang R, et al. Pharmacokinetics and bioavailability of cefquiome in healthy ducks. *Am J Vet Res*. 2011;72:122–126.
866. Zantop D. Medetomidine in birds. *Exotic DVM*. 1999;1:34.
867. Zantop D. Personal communication; 2002.

868. Zantop DW. Treatment of bile duct carcinoma in birds with carboplatin. *Exotic DVM*. 2000;2:76–78.
869. Zantop DW. Using leuprolide acetate to manage common avian reproductive problems. *Exotic DVM*. 2000;2:70.
870. Zenker W, Janovsky M, Kurzwell J, et al. Immobilisation of the Eurasian buzzard (*Buteo buteo*) with oral tiletamine/zolazepam. In: Lumeij JT, Remple JD, Redig PT, et al. *Raptor Biomedicine III*. Lake Worth, FL: Zoological Education Network; 2002:295–300.
871. Zenoble RD, Kemppainen RJ, Young DW, et al. Endocrine responses of healthy parrots to ACTH and thyroid stimulating hormone. *J Am Vet Med Assoc*. 1985;187:1116–1118.
872. Ziv G, Shem-Tov M, Glickman A, et al. Concentrations of amoxycillin and clavulanic acid in the serum of broilers during continuous and pulse-dosing of the drinking water. *J Vet Pharmacol Therap*. 1997;20(Suppl 1):183–184.
873. Ziv G, Shem-Tov M, Glickman A, et al. Serum oxytetracycline and chlortetracycline concentrations in broilers and turkeys treated with high doses of the drugs via the feed and water. *J Vet Pharmacol Therap*. 1997;20(Suppl 1):190–191.
874. Zollinger TJ, Gamble KC, Alvarado TP, et al. Rhabdomyolysis, steatitis, and coagulopathy in East African white pelicans (*Pelecanus onocrotalus*) and pink-backed pelicans (*Pelecanus rufescens*). *Proc Annu Conf Am Assoc Zoo Vet*; 2002:111–113.
875. Zuba JR, Singleton C, Papendick R. Avian chlamydiosis and doxycycline toxicity in a flock of free-contact rainbow lorikeets (*Trichoglossus haematodus haematodus*). considerations, concerns, and quandaries. *Proc Annu Conf Am Assoc Zoo Vet*; 2002:105–107.
876. Zucca P. Infectious diseases; arthropods. In: Samour J, ed. *Avian Medicine*. London: Harcourt Publ; 2000:219–245.
877. Zuchowska E. Some blood parameters in zoo birds. *Proc Euro Conf Avian*

Med Surg; 1993:493–506.

878. Zwiijnenberg RJG, Vulto AG, Van Miert AS, et al. Evaluation of antibiotics for racing pigeons (*Columba livia* var. domestica) available in the Netherlands. *J Vet Pharmacol Therap.* 1992;15:364–378.



# Chapter 6

## Sugar gliders

David M. Brust, Geoffrey W. Pye

TABLE 6-1 Antimicrobial and Antifungal Agents Used in Sugar Gliders.

| Agent                                          | Dosage                                                     | Comments                                                                          |
|------------------------------------------------|------------------------------------------------------------|-----------------------------------------------------------------------------------|
| Amikacin sulfate                               | 10 mg/kg IM q12h × 5 days <sup>37</sup>                    | Gram-negative pneumonia                                                           |
| Amoxicillin                                    | 30 mg/kg PO, IM divided q12-24h × 14 days <sup>20,30</sup> |                                                                                   |
|                                                | 30 mg/kg IM q24h <sup>12</sup>                             |                                                                                   |
| Amoxicillin/clavulanic acid (Clavamox, Pfizer) | 12.5 mg/kg PO, SC divided q12-24h <sup>30,41</sup>         | Injectable form not available in the United States                                |
| Cephalexin                                     | 30 mg/kg PO, SC divided q12-24h <sup>30,41</sup>           | Injectable form not available in the United States                                |
| Ciprofloxacin                                  | 10 mg/kg PO q12h <sup>30</sup>                             |                                                                                   |
| Enrofloxacin (Baytril, Bayer)                  | 2.5-5 mg/kg PO, IM q12-24h <sup>37</sup>                   | Tissue necrosis may occur when administered parenterally                          |
|                                                | 5 mg/kg PO, SC, IM q12h <sup>41</sup>                      |                                                                                   |
| Gentamicin                                     | 1.5-2.5 mg/kg SC, IM, IV q12h <sup>37</sup>                | Rarely indicated; use with caution; nephrotoxicity, need concurrent fluid therapy |
|                                                | 2 mg/kg SC, IM divided q12-24h <sup>30</sup>               |                                                                                   |
| Griseofulvin                                   | 20 mg/kg PO q24h × 30-60 days <sup>37</sup>                |                                                                                   |
| Itraconazole                                   | 5-10 mg/kg PO q12h <sup>40</sup>                           |                                                                                   |
| Lincomycin                                     | 30 mg/kg IM q24h × 7 days <sup>12</sup>                    | Dermatitis; dose can be divided q12-24h                                           |
| Metronidazole                                  | 25 mg/kg PO q12h × 7-10 days <sup>18</sup>                 | Compound at 5 mg/mL in tutti-fruity flavor <sup>4</sup>                           |
| Nystatin                                       | 2,000 U/kg PO q12h <sup>4</sup>                            | Candidiasis                                                                       |
|                                                | 5,000 U/kg q8h × 3 days <sup>37</sup>                      |                                                                                   |
|                                                | 22,000-25,000 U/kg q12-                                    |                                                                                   |

|                               |                                                      |                     |
|-------------------------------|------------------------------------------------------|---------------------|
| Penicillin                    | 24h <sup><a href="#">37</a></sup>                    | Also use probiotics |
| Trimethoprim/sulfamethoxazole | 10-20 mg/kg PO q12-24h <sup><a href="#">37</a></sup> |                     |
|                               | 15 mg/kg PO q12h <sup><a href="#">29,36</a></sup>    |                     |

TABLE 6-2 Antiparasitic Agents Used in Sugar Gliders.

| Agent                             | Dosage                                                                                                       | Comments                                                                                     |
|-----------------------------------|--------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------|
| Carbaryl powder (5%)              | Topical <sup><a href="#">2</a></sup>                                                                         | Ectoparasites; use sparingly; can be used in nest boxes                                      |
| Febantel (F)/pyrantel pamoate (P) | (F) 15 mg/kg + (P) 14.4 mg/kg PO <sup><a href="#">1</a></sup>                                                | Roundworms, strongyles                                                                       |
| Fenbendazole                      | 20-50 mg/kg PO q24h × 3 days, <sup><a href="#">3,30</a></sup> repeat in 14 days <sup><a href="#">4</a></sup> | Roundworms, hookworms, whipworms; cestodes; lower end of dosage range may be preferable      |
| Ivermectin                        | 0.2 mg/kg SC, repeat in 10-14 days <sup><a href="#">3,30</a></sup>                                           | Roundworms, hookworms, whipworms; acariasis                                                  |
| Levamisole                        | 10 mg/kg PO <sup><a href="#">37</a></sup>                                                                    |                                                                                              |
| Metronidazole                     | 25 mg/kg PO q12h <sup><a href="#">30</a></sup>                                                               | Intestinal protozoa; compound at 5 mg/mL in tutti-fruity flavor <sup><a href="#">4</a></sup> |
| Oxfendazole                       | 5 mg/kg PO single dose <sup><a href="#">3,36</a></sup>                                                       | Roundworms; cestodes (adult)                                                                 |
|                                   | 10-20 mg/kg PO <sup><a href="#">1</a></sup>                                                                  | Roundworms; cestodes (adult)                                                                 |
| Pyrethrin powder                  | Topical <sup><a href="#">33</a></sup>                                                                        | Ectoparasites; use products safe for kittens                                                 |
| Selamectin (Revolution, Pfizer)   | 6-18 mg/kg topically, repeat in 30 days <sup><a href="#">4</a></sup>                                         | Ectoparasites                                                                                |

TABLE 6-3 Chemical Restraint/Anesthetic Agents Used in Sugar Gliders.

| Agent         | Dosage                                                       | Comments                                   |
|---------------|--------------------------------------------------------------|--------------------------------------------|
| Acepromazine  | —                                                            | See butorphanol, ketamine for combinations |
| Atropine      | 0.01-0.02 mg/kg SC, IM <sup><a href="#">30</a></sup>         |                                            |
|               | 0.02-0.04 mg/kg SC, IM, IV <sup><a href="#">37</a></sup>     |                                            |
| Bupivacaine   | 0.1-1 mg/kg (local infiltrate) <sup><a href="#">40</a></sup> | Local anesthesia; dilute to avoid toxicity |
| Buprenorphine | —                                                            | Buprenorphine combination follows          |

|                                                   |                                                                                                  |                                                                                                                                                                                                                                                                                      |
|---------------------------------------------------|--------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Buprenorphine (Bu)/midazolam (Mi)/meloxicam (Mel) | (Bu) 0.01 mg/kg + (Mi) 0.1 mg/kg + (Mel) 0.2 mg/kg IM <sup><a href="#">40</a></sup>              | Give preemptively for the reduction of postsurgical self-mutilation                                                                                                                                                                                                                  |
| Butorphanol (Torbugesic, Fort Dodge)              | —                                                                                                | Butorphanol combination follows                                                                                                                                                                                                                                                      |
| Butorphanol (B)/acepromazine (A)                  | (B) 1.7 mg/kg + (A) 1.7 mg/kg PO <sup><a href="#">15</a></sup>                                   | Postoperative sedation and analgesia to prevent self-trauma to incision site; dilute with normal saline to administer                                                                                                                                                                |
| Dexmedetomidine (Dexdomitor, Pfizer)              | —                                                                                                | $\alpha$ -2 agonist that is the active optical enantiomer of racemic compound medetomidine; ½ the dose of medetomidine should be administered (although some suggest ⅝ instead of ½), but same volume due to concentration differences; limited data on safety or efficacy available |
| Diazepam                                          | 0.5-1 mg/kg IM <sup><a href="#">1</a></sup>                                                      | Lower dosage for sedation                                                                                                                                                                                                                                                            |
|                                                   | 0.5-2 mg/kg PO, IM, IV <sup><a href="#">37</a></sup>                                             |                                                                                                                                                                                                                                                                                      |
|                                                   | 1-2 mg/kg IV <sup><a href="#">4</a></sup>                                                        | Higher dosages IV for seizures                                                                                                                                                                                                                                                       |
| Enflurane                                         | To effect <sup><a href="#">30</a></sup>                                                          | Anesthesia                                                                                                                                                                                                                                                                           |
| Glycopyrrolate                                    | 0.01-0.02 mg/kg SC, IM, IV <sup><a href="#">20</a></sup>                                         | Controls salivation during sedation                                                                                                                                                                                                                                                  |
| Isoflurane                                        | 5% induction; <sup><a href="#">1</a></sup><br>1%-3% maintenance <sup><a href="#">35,39</a></sup> | Anesthetic of choice                                                                                                                                                                                                                                                                 |
| Ketamine                                          | —                                                                                                | Ketamine combinations follow                                                                                                                                                                                                                                                         |
|                                                   | 20 mg/kg IM <sup><a href="#">12</a></sup>                                                        | Followed with isoflurane                                                                                                                                                                                                                                                             |
|                                                   | 30-50 mg/kg IM <sup><a href="#">37</a></sup>                                                     |                                                                                                                                                                                                                                                                                      |
| Ketamine (K)/acepromazine (A)                     | (K) 10 mg/kg + (A) 1 mg/kg SC <sup><a href="#">15</a></sup>                                      | Postoperative sedation and analgesia to prevent self-trauma to incision site                                                                                                                                                                                                         |
|                                                   | (K) 30 mg/kg + (A) 2 mg/kg <sup><a href="#">37</a></sup> SC, IM                                  | For immobilization                                                                                                                                                                                                                                                                   |
| Ketamine (K)/medetomidine (Me)                    | (K) 2-3 mg/kg + (Me)                                                                             | For immobilization (see medetomidine)                                                                                                                                                                                                                                                |
|                                                   | 0.05-0.1 mg/kg <sup><a href="#">37</a></sup> SC, IM                                              |                                                                                                                                                                                                                                                                                      |
| Ketamine                                          | (K) 10-20 mg/kg + (Mi) 0.35-0.5                                                                  |                                                                                                                                                                                                                                                                                      |

|                                                    |                                                          |                                                                                                                                                     |
|----------------------------------------------------|----------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------|
| (K)/midazolam (Mi)                                 | mg/kg <sup>37</sup> SC, IM                               | Ketamine administered 5-10 min after the midazolam                                                                                                  |
| Ketamine<br>(K)/xylazine (X)                       | (K) 10-25 mg/kg<br>+ (X) 5 mg/kg <sup>37</sup><br>SC, IM | For immobilization                                                                                                                                  |
| Lidocaine                                          | 0.1-2 mg/kg<br>(local<br>infiltrate) <sup>40</sup>       | Topical anesthesia; 10-15 mg/kg may be a conservative<br>toxic dose <sup>9</sup>                                                                    |
|                                                    | <10 mg/kg q24h<br>(topical only) <sup>9</sup>            | Local anesthesia; dilute to avoid toxicity                                                                                                          |
| Medetomidine<br>(Domitor, Pfizer)                  | —                                                        | No longer commercially available, but can be obtained<br>through various compounding services; see<br>dexmedetomidine; see ketamine for combination |
| Meloxicam<br>(Metacam,<br>Boehringer<br>Ingelheim) | 0.2 mg/kg PO,<br>SC <sup>4</sup>                         | NSAID; analgesia; see buprenorphine for combination                                                                                                 |
| Midazolam                                          | —                                                        | See buprenorphine, ketamine for combinations                                                                                                        |
|                                                    | 0.25-0.5 mg/kg<br>IM <sup>19</sup>                       | Anxiolytic; preanesthetic; sedation                                                                                                                 |
| Sevoflurane                                        | 1-5% to<br>effect <sup>5,30</sup>                        | Anesthesia                                                                                                                                          |
| Tiletamine/zolazepam<br>(Telazol, Fort Dodge)      | —                                                        | Do not use; has caused neurologic syndromes and death in<br>squirrel gliders at 10 mg/kg <sup>11</sup>                                              |
| Xylazine                                           | —                                                        | See ketamine for combination                                                                                                                        |
| Yohimbine                                          | 0.2 mg/kg IV <sup>37</sup>                               | Reversal of xylazine                                                                                                                                |

TABLE 6-4 Analgesic Agents Used in Sugar Gliders.

| Agent                                      | Dosage                                          | Comments                                             |
|--------------------------------------------|-------------------------------------------------|------------------------------------------------------|
| Buprenorphine                              | 0.005-0.01<br>mg/kg SC, IM<br>q8h <sup>40</sup> | Analgesia                                            |
|                                            | 0.01-0.03 mg/kg<br>PO, SC q12h <sup>37</sup>    |                                                      |
| Butorphanol (Torbugesic,<br>Fort Dodge)    | 0.1-0.5 mg/kg<br>SC, IM q6-8h <sup>37</sup>     | Analgesia                                            |
|                                            | 0.5 mg/kg IM<br>q8h <sup>35</sup>               |                                                      |
| Flunixin meglumine<br>(Banamine, Schering- | 0.1-1 mg/kg IM<br>q12-24h <sup>24,29</sup>      | Analgesia; nonsteroidal antiinflammatory; use for up |

|                                           |                                         |                                                                                                              |
|-------------------------------------------|-----------------------------------------|--------------------------------------------------------------------------------------------------------------|
| Plough)                                   |                                         | to 3 days                                                                                                    |
| Meloxicam (Metacam, Boehringer Ingelheim) | 0.1-0.2 mg/kg PO, IM q12h <sup>5</sup>  | Analgesia; nonsteroidal antiinflammatory; animals like sweet taste; use 0.5 mg/mL concentration <sup>5</sup> |
|                                           | 0.1-0.2 mg/kg PO, SC q24h <sup>37</sup> |                                                                                                              |

TABLE 6-5 Miscellaneous Agents Used in Sugar Gliders.

| Agent                            | Dosage                                                                  | Comments                                                                                                                  |
|----------------------------------|-------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------|
| Calcitonin                       | 50-100 U/kg <sup>35</sup>                                               | Nutritional osteodystrophy; ensure serum calcium levels are normal prior to use; salmon origin                            |
| Calcium glubionate               | 150 mg/kg PO q24h <sup>40</sup>                                         | Nutritional osteodystrophy; calcium deficiency                                                                            |
| Calcium gluconate                | 100 mg/kg SC q12h × 3-5 days; dilute in saline to 10 mg/mL <sup>5</sup> | Nutritional osteodystrophy; calcium deficiency                                                                            |
| Calcium glycerophosphate/lactate | 7 mg/kg IM <sup>32</sup>                                                | Nutritional osteodystrophy; calcium deficiency                                                                            |
| Cisapride                        | 0.25 mg/kg q8-24h PO, IM <sup>20,37</sup>                               | Gastrointestinal motility enhancer                                                                                        |
| Dexamethasone                    | 0.1-0.6 mg/kg SC, IM, IV <sup>30</sup>                                  | Antiinflammatory; allergies                                                                                               |
|                                  | 0.2 mg/kg SC, IM, IV q12-24h <sup>37</sup>                              |                                                                                                                           |
|                                  | 0.5-2 mg/kg SC, IM, IV <sup>20</sup>                                    | Shock                                                                                                                     |
| Doxapram                         | 2 mg/kg IV <sup>26</sup>                                                | General CNS stimulant; respiratory stimulant; can also place under tongue                                                 |
| Enalapril                        | 0.22-0.44 mg/kg PO q24h <sup>37</sup>                                   | Vasodilator for the treatment of heart failure and hypertension; compound at 1 mg/mL in tutti-fruity flavor <sup>26</sup> |
|                                  | 0.5 mg/kg PO q24h <sup>26</sup>                                         |                                                                                                                           |
| Epinephrine                      | 0.003 mg/kg IV <sup>26</sup>                                            | Stimulates heart; antagonizes effects of histamine; raises blood sugar                                                    |
| Fluoxetine                       | 1-5 mg/kg PO q8h <sup>14,25</sup>                                       | Self-mutilation; use liquid form                                                                                          |
| Furosemide                       | 1-4 mg/kg SC, IM q6-8h <sup>23,37</sup>                                 | Diuretic                                                                                                                  |
|                                  | 1-5 mg/kg PO q12h <sup>37</sup>                                         |                                                                                                                           |
| L-carnitine                      | 100 mg/kg PO q12h <sup>37</sup>                                         |                                                                                                                           |
| Metoclopramide                   | 0.05-0.1 mg/kg PO, SC, IM q6-12h prn <sup>20,37</sup>                   | Gastrointestinal motility enhancer                                                                                        |

|                   |                                                |                              |
|-------------------|------------------------------------------------|------------------------------|
| Prednisolone      | 0.1-0.2 mg/kg PO, SC, IM<br>q24h <sup>37</sup> | Antiinflammatory             |
| Vitamin A         | 500-5000 U/kg IM <sup>30</sup>                 | Skin disorders               |
| Vitamin B complex | 0.01-0.02 mL/kg <sup>37</sup> SC, IM           | Stings on injection; dilute  |
|                   | 0.02-0.2 mL/kg SC, IM <sup>30</sup>            | Use small animal formulation |
| Vitamin E         | 10 U/kg SC <sup>4</sup>                        | Neurological conditions      |
| Vitamin K         | 2 mg/kg SC q24-72h <sup>37</sup>               |                              |

TABLE 6-6 Hematologic and Serum Biochemical Values of Sugar Gliders.<sup>a</sup>

| Measurement                                      | <i>Sugar Gliders:<br/>A Complete<br/>Veterinary Care<br/>Guide</i> <sup>1,2</sup> | International Species<br>Information System <sup>13</sup> | Midwest Bird and<br>Exotic Animal Hospital,<br>Illinois, USA <sup>14,15</sup> |
|--------------------------------------------------|-----------------------------------------------------------------------------------|-----------------------------------------------------------|-------------------------------------------------------------------------------|
| <b>Hematology</b>                                |                                                                                   |                                                           |                                                                               |
| PCV (%)                                          | 51-54 (62)                                                                        | 43 ± 4 (24)                                               | 43 ± 13 (10)                                                                  |
| RBC (10 <sup>6</sup> /μL)                        | 8.31-8.83 (53)                                                                    | 7.8 ± 0.9 (20)                                            | 6.1 ± 1.4 (10)                                                                |
| Hgb (g/dL)                                       | 15.8-16.9 (53)                                                                    | 15.4 ± 1.6 (21)                                           | 11.6 ± 4.7 (10)                                                               |
| MCH (pg)                                         | 18.8-19.4 (53)                                                                    | 19.9 ± 1.3 (20)                                           | —                                                                             |
| MCHC (g/dL)                                      | 30.6-31 (53)                                                                      | 35.1 ± 2 (21)                                             | —                                                                             |
| MCV (fL)                                         | 60-68 (54)                                                                        | 56.8 ± 5.4 (20)                                           | —                                                                             |
| WBC (10 <sup>3</sup> /μL)                        | 5.49-9.31 (62)                                                                    | 7.7 ± 5.5 (23)                                            | 8.6 ± 5.1 (10)                                                                |
| Segmented neutro-<br>phils (10 <sup>3</sup> /μL) | 1.46-2.2 (61)                                                                     | 1.2 ± 1 (23)                                              | 31% ± 16% (10)                                                                |
| Band cells (10 <sup>3</sup> /μL)                 | —                                                                                 | 0.14 ± 0.04 (3)                                           | 0% (10)                                                                       |
| Lymphocytes (10 <sup>3</sup> /μL)                | 3.69-7.16 (62)                                                                    | 6.2 ± 5.1 (23)                                            | 64% ± 17% (10)                                                                |
| Monocytes (10 <sup>3</sup> /μL)                  | 0.11-0.17 (45)                                                                    | 0.19 ± 0.17 (18)                                          | 3% ± 3% (10)                                                                  |
| Eosinophils (10 <sup>3</sup> /μL)                | 0.09-0.28 (10)                                                                    | 0.18 ± 0.24 (16)                                          | 2% ± 2% (10)                                                                  |
| Basophils (10 <sup>3</sup> /μL)                  | 0.03-0.06 (8)                                                                     | 0.04 (1)                                                  | 0% (10)                                                                       |
| NRBC/100 WBC                                     | —                                                                                 | 2 ± 1 (7)                                                 | —                                                                             |
| Platelets (10 <sup>3</sup> /μL)                  | 292-400 (53)                                                                      | 728 ± 176 (3)                                             | 162 ± 62 (10)                                                                 |



| Chemistries              |                |                |                               |
|--------------------------|----------------|----------------|-------------------------------|
| ALP (U/L)                | 89-115 (75)    | 231 ± 93 (7)   | —                             |
| ALT (U/L)                | 97-137 (81)    | 67 ± 38 (16)   | 100 ± 83 (11)                 |
| AST (U/L)                | 54-100 (38)    | 70 ± 65 (17)   | 147 ± 137 (11)                |
| Bilirubin, total (mg/dL) | 0.12-0.7 (72)  | 0.3 ± 0.2 (15) | 0.6 ± 0.3 (11)                |
| Calcium (mg/dL)          | 8.5-8.9 (97)   | 7.4 ± 2.9 (7)  | 8.0 ± 1.6 (11)                |
| Chloride (mEq/L)         | 106-109 (94)   | 105 ± 3 (5)    | —                             |
| Cholesterol (mg/dL)      | 112-124 (78)   | 159 ± 49 (6)   | —                             |
| CPK (U/L)                | 1081-1637 (47) | 639 ± 477 (5)  | 2596 ± 3840 (11) <sup>c</sup> |
| Creatinine (mg/dL)       | 0.5-0.6 (100)  | 0.7 ± 0.3 (8)  | 0.4 ± 0.2 (11)                |

| Sugar Gliders:<br>A Complete<br>Veterinary Care<br>Guide <sup>1,2</sup><br>International Species<br>Information System <sup>3</sup><br>Midwest Bird and<br>Exotic Animal Hospital,<br>Illinois, USA <sup>4,38</sup> |              |                |                |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------|----------------|----------------|
| Measurement                                                                                                                                                                                                         |              |                |                |
| Glucose (mg/dL)                                                                                                                                                                                                     | 153-172 (85) | 135 ± 75 (17)  | 156 ± 40 (11)  |
| LDH (U/L)                                                                                                                                                                                                           | —            | 246 ± 33 (3)   | —              |
| Phosphorus (mg/dL)                                                                                                                                                                                                  | 4.4-6.1 (62) | 6.7 ± 2.0 (6)  | 4.9 ± 2.8 (11) |
| Potassium (mEq/L)                                                                                                                                                                                                   | 4.6-5.5 (93) | 3.3 ± 0.7 (5)  | 5.8 ± 3.9 (11) |
| Protein, total (g/dL)                                                                                                                                                                                               | 6.7-7 (92)   | 6.0 ± 0.6 (15) | 5.6 ± 0.7 (11) |
| Albumin (g/dL)                                                                                                                                                                                                      | 3.1-4.6 (99) | 3.8 ± 0.7 (8)  | 4.1 ± 0.8 (11) |
| Globulin (g/dL)                                                                                                                                                                                                     | 2.9-3.1 (92) | 2.3 ± 0.8 (7)  | —              |
| Sodium (mEq/L)                                                                                                                                                                                                      | 139-143 (92) | 142 ± 4 (5)    | 137 ± 10 (11)  |
| Urea nitrogen (mg/dL)                                                                                                                                                                                               | 15-18 (100)  | 19 ± 11 (16)   | 25 ± 9.2 (11)  |

<sup>a</sup>Sample size is presented in parentheses.  
<sup>b</sup>Values shown are the 95% confidence intervals after outliers were removed; blood was collected from the cranial vena cava; glucose levels were measured immediately after collection.  
<sup>c</sup>In the author's opinion, these values are extremely high and should not be used as a normal reference range.

TABLE 6-7 Biologic and Physiologic Values of Sugar Gliders. [1,3,4,7,8,10,13,27,28,31,38,42-44](#)

| Parameter                  | Normal Values |
|----------------------------|---------------|
| Average life span (wild)   |               |
| Male                       | 4-5 years     |
| Female                     | 5-7 years     |
| Maximum reported life span |               |

|                            |                                                                 |
|----------------------------|-----------------------------------------------------------------|
| Captivity                  | 15 years                                                        |
| Wild                       | 9 years                                                         |
| Colony size (wild)         | 7 (avg) (1 dominant male, 2 subordinate males, 4 adult females) |
| Colony size (captive)      | Minimum 2 (more is better)                                      |
| Adult weight <sup>a</sup>  | Male, 115-160 g (avg 140 g)<br>Female, 95-135 g (avg 115 g)     |
| Body length                | 16-21 cm (avg 17 cm)                                            |
| Tail length                | 16.5-21 cm (avg 19 cm)                                          |
| Heart rate                 | 200-300 beats/min                                               |
| Respiratory rate           | 16-40 breaths/min                                               |
| Cloacal temperature        | 36.2°C ± 0.4°C (97.2°F ± 0.7°F)                                 |
| Torpor cloacal temperature | ≤15°C (59°F)                                                    |
| Thermoneutral zone         | 27-31°C (81-88°F)                                               |
| Basal metabolic rate       | 2.54 (weight in kg) <sup>0.75</sup>                             |
| Estrus cycle               |                                                                 |
| Type                       | Seasonally polyestrous                                          |
| Length                     | 29 days                                                         |
| Gestation period           | 15-17 days                                                      |
| Litter size                | 1-4 (usually 2)                                                 |
| Birth weight               | 0.19 g                                                          |
| Pouch emergence            | 50-74 days (usually 60 days)                                    |
| Weaning age                | 85-120 days (usually 100 days)                                  |
| Dispersal from nest        | 7-10 months                                                     |
| Sexual maturity            | Male, 12-14 months; female 8-12 months                          |

<sup>a</sup> Weights are for adult sugar gliders (*Petaurus breviceps breviceps*). Many sugar gliders in the United States are the New Guinean subspecies, which are smaller. Weights of 80-130 g are more typical. [17](#),[29](#),[33](#),[35](#)

TABLE 6-8 Urinalysis Values of Sugar Gliders.<sup>4</sup>

| Measurement | Avg | Range <sup>a,b</sup> |
|-------------|-----|----------------------|
|             |     |                      |



|                  |       |                   |
|------------------|-------|-------------------|
| Specific gravity | 1.030 | 1.020-1.040 (103) |
| pH               | 6.2   | 6-6.3 (98)        |
| Protein (mg/dL)  | 12    | 9.5-14.6 (82)     |

<sup>a</sup> Values shown are the 95% confidence intervals after outliers were removed; analysis performed using IDEXX Vetlab UA™.

<sup>b</sup> Sample size is presented in parentheses.

TABLE 6-9 Growth and Development of Sugar Gliders.<sup>3,5,6</sup>

| Stage 1: In Pouch                          |            |                                                                                |          |                                                                         |
|--------------------------------------------|------------|--------------------------------------------------------------------------------|----------|-------------------------------------------------------------------------|
| Age (days)                                 | Weight (g) | Head (mm)                                                                      | Leg (mm) | Key Developmental Characteristics                                       |
| 1                                          | 0.2        | —                                                                              | —        | Mouth and forelimbs most developed feature                              |
| 20                                         | 0.8        | 11                                                                             | 6        | Ears free from head; papillae of mystacial vibrissae (whiskers) visible |
| 30                                         | 1.6        | 14                                                                             | 9        | —                                                                       |
| 35                                         | 2          | —                                                                              | —        | Mystacial vibrissae erupt; ears pigmented                               |
| 40                                         | 3.2        | 17                                                                             | 12       | Start to pigment on shoulders; eye slits present                        |
| 50                                         | 6.2        | 20                                                                             | 16       | Typical detachment from teat and emergence from pouch at 50-60 days     |
| Stage 2: Out of Pouch (OOP) <sup>a,b</sup> |            |                                                                                |          |                                                                         |
| Age (weeks)                                | Weight (g) | Key Developmental Characteristics                                              |          |                                                                         |
| 1                                          | 8-18       | Dorsal stripe developing; little to no fur; slick tail; closed eyes            |          |                                                                         |
| 2                                          | 12-22      | Eyes open at approximately 17-21 days; fur lengthens                           |          |                                                                         |
| 3                                          | 17-29      | Very fine fur, except abdominal area; tail still slick; eyes still closed      |          |                                                                         |
| 4                                          | 18-35      | Fur becoming more prominent; tail beginning to fluff; weaning begins           |          |                                                                         |
| 5                                          | 19-39      | Complete fur coverage; light fur on abdominal area; tail continues to fill out |          |                                                                         |
| 6                                          | 20-45      | Tail fully fluffed out; abdominal area fully furred; mostly weaned             |          |                                                                         |
| 7                                          | 21-60      | Very active at night; eating mainly solid foods                                |          |                                                                         |
| 8                                          | 23-75      | Fully self-sufficient and weaned                                               |          |                                                                         |

<sup>a</sup>On a practical level, estimating an exact out of pouch (OOP) date is often problematic because of the nocturnal nature of the animal and protectiveness of parents; joeys often exhibit wide weight differentials at the same age; the most reliable method for estimating age is to visually assess key distinguishing characteristics of their physical development, especially the abdominal area and tail.<sup>4</sup>

<sup>b</sup>Once joey is observed out of pouch, age is typically measured in weeks.<sup>1</sup>

TABLE 6-10 Dietary Components for Sugar Gliders in Captivity.<sup>2,4</sup>

|                             |                                                                                                                                                                                                                                       |
|-----------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Common presentations        | Obesity, malnutrition, and osteodystrophy often caused by nutritional inconsistencies of homemade diets and excessive sweet and fatty items                                                                                           |
| Daily consumption           | 15-20% of body weight                                                                                                                                                                                                                 |
| Pelleted kibble             | Nutritionally-balanced, commercial sugar glider kibble (Glide-R-Chow™ [ <a href="http://www.sugarbears.com">www.sugarbears.com</a> ], NutriMax™ [ <a href="http://www.vetspride.com">www.vetspride.com</a> ])                         |
| Fresh fruits and vegetables | Apples, apricots, bananas, berries, corn, grapes, green beans, kiwifruit, mangos, melons, oranges, paw paw (papaya), peas, sweet potatoes, squash, and watermelon                                                                     |
| Supplement                  | Calcium-based multivitamin supplement formulated specifically for sugar gliders (Glide-A-Mins™ [ <a href="http://www.sugarbears.com">www.sugarbears.com</a> ], VitaMax™ [ <a href="http://www.vetspride.com">www.vetspride.com</a> ]) |
| Treats <sup>a</sup>         | Must be strictly controlled; applesauce, yogurt, and limited invertebrates such as mealworms, grasshoppers, moths, fly pupae, and crickets                                                                                            |
| Bottled or filtered water   | Refresh drip water bottle daily; introduction of weighted container such as small ashtray may also be necessary for young joeys                                                                                                       |
| Blossoms and branches       | <i>Eucalyptus</i> , <i>Banksia</i> , <i>Leptospermum</i> , <i>Grevillea</i> , <i>Acacia</i> , <i>Melaleuca</i> , <i>Callistemon</i> , and <i>Hakea</i>                                                                                |

<sup>a</sup> Sugar gliders will preferentially eat sweet/fatty items to excess and to the exclusion of more nutritious foods, so they should not be presented with too wide a selection of foods.

TABLE 6-11 Suggested Sugar Glider Diets.<sup>4,22</sup>

|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Diet 1<sup>4</sup></b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
| <p><b>75%:</b> Nutritionally balanced, commercial sugar glider kibble: 1-2 oz (28-56 g)/day/animal; available free choice in cage at all times (Glide-R-Chow™ [<a href="http://www.sugarbears.com">www.sugarbears.com</a>], NutriMax™ [<a href="http://www.vetspride.com">www.vetspride.com</a>])</p> <p><b>25%:</b> Fresh fruits and vegetables: approximately ¼ of an apple, or the equivalent in mixed fruits/vegetables per animal per day; introduce each evening and remove leftovers in morning; apples, apricots, bananas, berries, corn, grapes, green beans, kiwifruit, mangos, melons, oranges, paw paw (papaya), peas, sweet potatoes, squash, and watermelon</p> <p><b>Calcium-based multivitamin supplement:</b> Sprinkle lightly on fruits/vegetables every other day; can also be mixed into applesauce or fruit baby food and hand-fed daily to promote bonding (Glide-A-Mins™ [<a href="http://www.sugarbears.com">www.sugarbears.com</a>], VitaMax™ [<a href="http://www.vetspride.com">www.vetspride.com</a>])</p> <p><b>Treats:</b> Not to exceed 5% of daily diet; introduce gradually and individually, checking for diarrhea; treat items must be strictly controlled, and may include: fruits, applesauce, yogurt, and invertebrates such as mealworms, grasshoppers, moths, fly pupae, and crickets</p> |

|                                                                                                                                                                                                                                                                                                                                                                                                              |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Diet 2</b> <a href="#">a-c,16</a>                                                                                                                                                                                                                                                                                                                                                                         |
| <b>50%:</b> Leadbeater’s mixture (150 mL warm water; 150 mL honey; 1 shelled, hard-boiled egg; 25 g high protein baby cereal; 1 tsp vitamin/mineral supplement)                                                                                                                                                                                                                                              |
| <ul style="list-style-type: none"><li>• Mix warm water and honey</li><li>• In separate container, blend egg until homogenized</li><li>• Gradually add honey/water, then vitamin powder, then baby cereal, and blend after each addition until smooth</li><li>• Keep refrigerated until served</li></ul>                                                                                                      |
| <b>50%:</b> Insectivore/omnivore diet (e.g., Mazuri Brand, Purina Mills, St. Louis, MO; Reliable Protein Products, Palm Desert, CA; ZuPreem, Mission, KS)                                                                                                                                                                                                                                                    |
| <b>Diet 3</b> <a href="#">d,17,21</a>                                                                                                                                                                                                                                                                                                                                                                        |
| <ul style="list-style-type: none"><li>• Apple: 3 g; banana/corn: 3 g; grapes/kiwifruit: 3 g; orange with skin: 4 g; pear: 2 g; rockmelon/melon/paw paw (payaya): 2 g</li><li>• Sweet potato: 3 g</li><li>• Dog kibble: 1.5 g</li><li>• Fly pupae: 1 tsp</li><li>• Leadbeater’s mix (see above): 2 tsp</li><li>• Day-old-chick (1 day a week)</li><li>• Large insects or mealworms (when available)</li></ul> |

<sup>a</sup> Insects can be added to this diet to help prevent dental problems.

<sup>b</sup> Feed fresh portions in evening; chop items together to reduce only favorite foods being selected; can offer treats (meats, diced fruits with multiple vitamin/mineral powder, bee pollen, worms, and crickets or other gut-loaded insects) at approximately 5% of daily intake.

- <sup>c</sup> Pelleted sugar glider food (e.g., Marion Zoological, Plymouth, MN) might be preferable to other dry omnivore diets.
- <sup>d</sup> Recipe feeds two animals; without native foods (e.g., North America), add calcium carbonate to this diet.

TABLE 6-12 Feed Estimates for Hand-Rearing Sugar Gliders.<sup>a-d,6</sup>

| Age (days) | Feed (mL/day)                     | Wombaroo Possum Milk Replacer <sup>e</sup>       |
|------------|-----------------------------------|--------------------------------------------------|
| 20         | 0.7                               | Formula “<0.8”                                   |
| 30         | 1.1                               | Formula “<0.8”                                   |
| 40         | 1.8                               | Formula “<0.8”                                   |
| 50         | 3                                 | Formula “<0.8”                                   |
| 51-53      | 4 (3 mL [“<0.8”] + 1 mL [“>0.8”]) | Transition from Formula “<0.8” to Formula “>0.8” |
| 54-56      | 4 (2 mL [“<0.8”] + 2 mL [“>0.8”]) | Transition from Formula “<0.8” to Formula “>0.8” |
| 57-59      | 4 (1 mL [“<0.8”] + 3 mL [“>0.8”]) | Transition from Formula “<0.8” to Formula “>0.8” |
| 60         | 3                                 | Formula “>0.8”                                   |
| 70         | 4                                 | Formula “>0.8”                                   |
| 80         | 6                                 | Formula “>0.8”                                   |
| 90         | 7                                 | Formula “>0.8”                                   |
| 100        | 8                                 | Formula “>0.8”                                   |

- <sup>a</sup> Using [Table 6-9](#), estimate the age of the sugar glider using developmental characteristics and weight measurements. Feed the volume listed according to the estimated age of the sugar glider. In emaciated joeys, the head and leg measurement is a more accurate method to determine age than the animal’s weight.
- <sup>b</sup> Note that marsupial milk changes in composition and energy as the joey develops. Therefore, there are two formulas of Wombaroo Possum Milk Replacer that are used for hand-rearing sugar gliders. Formula “<0.8” is for younger joeys; Formula “>0.8” is for gliders out of the pouch. When a joey has fully emerged from the pouch, it then uses Formula “>0.8” entirely.
- <sup>c</sup> Wombaroo Possum Milk Replacer “<0.8” and “>0.8” is available in the United States from the Exotic Nutrition Co, Newport News, VA; (866) 988-0301;

[exoticdiet@cox.net](mailto:exoticdiet@cox.net) or from Perfect Pets Inc, Belleville, MI; (800) 366-8794; [www.wombaroo.com](http://www.wombaroo.com).

<sup>d</sup> For hand-rearing procedures, refer to Barnes<sup>1</sup> and Ness and Booth.<sup>36</sup>

## References

1. Barnes M. Sugar gliders. In: Gage LJ, ed. *Hand-rearing Wild and Domestic Mammals*. Ames: Iowa State Press; 2002:55–62.
2. Booth RJ. Medicine and husbandry. dasyurids, possums, and bats. Proc 233rd Wildl Post Grad Comm Vet Sci; 1994:423–441.
3. Booth RJ. General husbandry and medical care of sugar gliders. In: Bonagura JD, ed. *Kirk's Current Veterinary Therapy XIII: Small Animal Practice*. Philadelphia: WB Saunders Co; 2000:1157–1163.
4. Brust D. Sugar Gliders. A Complete Veterinary Care Guide. Sugarland, TX: Veterinary Interactive Publications; 2009.
5. Brust DM. What every veterinarian needs to know about sugar gliders. *Exotic DVM*. 2009;11:32–41.
6. Doneley B. Hand-rearing orphan marsupials. *Exotic DVM*. 2002;4:79–82.
7. Fleming MR. Thermoregulation and torpor in the sugar glider, *Petaurus breviceps* (Marsupialia. Petauridae). *Aust J Zool*. 1980;28:521–534.
8. Grzimek B, Ganslosser U. Ringtails and gliders. In: Grzimek B, ed. *Grzimek's Encyclopedia of Mammals*, Vol 1. New York: McGraw-Hill; 1990:318–324.
9. Heard D. Available at [www.vin.com/Members/boards/discussionviewer.aspx?DocumentId=4095629](http://www.vin.com/Members/boards/discussionviewer.aspx?DocumentId=4095629), Aug 19, 2009. Accessed
10. Henry SR, Suckling GC. A review of the ecology of the sugar glider. In: Smith PA, Hume ID. *Possums and Gliders*. Sydney: Australian Mammal Society; 1984:355–358.

11. Holz P. Immobilization of marsupials with tiletamine and zolazepam. *J Zoo Wildl Med.* 1992;23:426–428.
12. Hough I, Reuter RE, Rahaley RS, et al. Cutaneous lymphosarcoma in a sugar glider. *Aust Vet J.* 1992;69:93–94.
13. International Species Information System (ISIS). Apple Valley, MN: 12101 Johnny Cake Rd; 2002.
14. Johnson D. *Diagnosing and treating sugar gliders.* Proc West Vet Conf; 2004.
15. Johnson SD. Orchiectomy of the mature sugar glider (*Petaurus breviceps*). *Exotic Pet Pract.* 1997;2:71.
16. Johnson-Delaney C. Feeding sugar gliders. *Exotic DVM.* 1998;1:4.
17. Johnson-Delaney CA. The marsupial pet. sugar gliders, exotic possums, and wallabies. *Proc Annu Conf Assoc Avian Vet.* 1998:329–339.
18. Johnson-Delaney CA. Medical problems in the sugar glider. *Exotic Pet Pract.* 2000;5:33–37.
19. Johnson-Delaney CA. Medical update for sugar gliders. *Exotic DVM.* 2000;2:91–93.
20. Johnson-Delaney CA. Therapeutics of companion exotic marsupials. *Vet Clin North Am Exotic Anim Pract.* 2000;3:173–181.
21. Johnson-Delaney CA. Marsupial nutrition and physiology. *Exotic DVM.* 2002;4:75–77.
22. Johnson-Delaney CA. Marsupials. *Exotic Companion Medicine Handbook.* Johnson-Delaney CA. West Palm Beach: Zoological Education Network; 2000.
23. Johnson-Delaney CA. Other small mammals. In: Meredith A, Redrobe S. *BSAVA Manual of Exotic Pets.* 4th ed. Quedgeley: British Small Animal Veterinary Association; 2002:102–115.

24. Johnson-Delaney CA. Practical marsupial medicine. *Annu Conf Assoc Exotic Mam Vet*; 2006:51–60.
25. Johnson-Delaney CA. Marsupials. Meredith A, Johnson-Delaney C. *BSAVA Manual of Exotic Pets*, 5th ed, Quedgeley: British Small Animal Veterinary Association, 2010.
26. Lennox AM. Emergency and critical care procedures in sugar gliders (*Petaurus breviceps*), African hedgehogs (*Atelerix albiventris*), and prairie dogs (*Cynomys* spp). *Vet Clin North Am Exotic Anim Pract*. 2007;10:533–555.
27. Lindenmayer D. *Gliders of Australia. a Natural History*. Sydney: University of New South Wales Press; 2002.
28. MacPherson C. *Sugar Gliders (A Complete Pet Owner's Manual)*. Hong Kong: Barron's Educational Series; 1997.
29. MacPherson C. Personal communication; 1998.
30. Morrissey JK, Carpenter JW. Formulary. In: Quesenberry KE, Carpenter JW. *Ferrets, Rabbits, and Rodents: Clinical Medicine and Surgery*. 2nd ed. St Louis: Saunders/Elsevier; 2004:436–444.
31. Nagy KA, Suckling GC. Field energetics and water balance of sugar gliders, *Petaurus breviceps* (Marsupialia: Petauridae). *Aust J Zool*. 1985;33:683–691.
32. Nelson S. A presumed case of “milk fever” hypocalcemia in a sugar glider. *Exotic DVM*. 2000;1:42.
33. Ness RD. Introduction to sugar gliders. *Proc North Am Vet Conf*; 1998:864–865.
34. Ness RD. Clinical pathology and sample collection of exotic small mammals. *Vet Clin North Am Exotic Anim Pract*. 1999;2:591–620.
35. Ness RD. Sugar glider (*Petaurus breviceps*). general husbandry and medicine. *Proc Exotic Small Mam Med Mgt (Annu Conf Assoc Avian Vet)*; 2000:99–107.

36. Ness RD, Booth R. Sugar gliders. In: Quesenberry KE, Carpenter JW. *Ferrets, Rabbits, and Rodents: Clinical Medicine and Surgery*. 2nd ed. St Louis: Saunders/Elsevier; 2004:330–338.
37. Ness RD, Johnson-Delaney C. Sugar gliders. In: Quesenberry KE, Carpenter JW. *Ferrets, Rabbits, and Rodents: Clinical Medicine and Surgery*. 3rd ed. St. Louis: Saunders/Elsevier; 2012:393–410.
38. Nowak RM. Petauridae. gliding and striped possums. Nowak RM, ed. Walker's Mammals of the World, 6th ed. Baltimore: Johns Hopkins University Press; 1999;Vol 1:139–140.
39. Pye GW. Marsupial, insectivore, and chiropteran anesthesia. *Vet Clin North Am Exotic Anim Pract*. 2001;4:211–237.
40. Pye GW. Personal observations; 2010.
41. Pye GW, Carpenter JW. A guide to medicine and surgery in sugar gliders. *Vet Med*. 1999;94:891–905.
42. Strahan R. *The Mammals of the World*. Chatswood: Reed Books; 1995.
43. Tyndale-Biscoe CH. Reproductive physiology of possums and gliders. In: Smith PA, Hume ID. *Possums and Gliders*. Sydney: Australian Mammal Society; 1984:79–87.
44. Tyndale-Biscoe CH, Renfree M. *Reproductive Physiology of Marsupials*. Cambridge: Cambridge University Press; 1987.



# Chapter 7

## Hedgehogs

James W. Carpenter, Christopher J. Marion

TABLE 7-1 Antimicrobial Agents Used in Hedgehogs.

| Agent                                          | Dosage                                        | Comments                                                                                                         |
|------------------------------------------------|-----------------------------------------------|------------------------------------------------------------------------------------------------------------------|
| Amikacin                                       | 2.5-5 mg/kg IM q8-12h <sup>24</sup>           | Make sure animal is hydrated; do not use in animals with renal disease <sup>18</sup>                             |
|                                                | 1 mg per 4 g powder <sup>23</sup>             | Polymethylmethacrylate (PMMA) beads                                                                              |
| Amoxicillin                                    | 15 mg/kg PO, SC, IM q12h <sup>12,35</sup>     | Palatable to most hedgehogs <sup>8</sup>                                                                         |
| Amoxicillin/clavulanic acid (Clavamox, Pfizer) | 12.5 mg/kg PO q12h <sup>28,37</sup>           | Palatable to most hedgehogs <sup>8</sup>                                                                         |
| Ampicillin                                     | 10 mg/kg IM q12h <sup>12,14,35</sup>          | Not recommended or use with caution <sup>18</sup>                                                                |
| Ceftiofur (Naxcel, Pfizer)                     | 20 mg/kg SC q12-24h <sup>24</sup>             | Polymethylmethacrylate (PMMA) beads                                                                              |
|                                                | 1 g per 20 mL powder <sup>23</sup>            |                                                                                                                  |
| Cephalexin                                     | 25 mg/kg PO q8h <sup>24</sup>                 | May make stools loose <sup>18</sup>                                                                              |
| Chloramphenicol                                | 30 mg/kg IM q12h <sup>12,14</sup>             | Acute salmonellosis                                                                                              |
|                                                | 30-50 mg/kg PO, SC, IM, IV q12h <sup>35</sup> |                                                                                                                  |
|                                                | 50 mg/kg PO, SC, IM q12h <sup>10,12,14</sup>  |                                                                                                                  |
| Chlorhexidine                                  | Topical <sup>35</sup> q8-12h <sup>18</sup>    | Bacterial dermatitis; traumatic skin lesions; wound treatments; soaking (e.g., appendages); use properly diluted |
| Chlorhexidine shampoo                          | 2-3% shampoo <sup>24</sup>                    | Bacterial/mycotic dermatitis                                                                                     |
| Chlortetracycline                              | 5-20 mg/kg PO q12h <sup>28</sup>              |                                                                                                                  |
| Ciprofloxacin (Cipro, Bayer)                   | 5-20 mg/kg PO q12h <sup>28</sup>              |                                                                                                                  |
| Clarithromycin                                 | 5.5 mg/kg PO q12h <sup>28</sup>               |                                                                                                                  |

|                                                                              |                                                                                                     |                                                                                                      |
|------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------|
| Clindamycin                                                                  | 5.5-10 mg/kg PO q12h <sup><a href="#">24,37</a></sup>                                               | Anaerobes; dental disease                                                                            |
| Doxycycline                                                                  | 2.5-10 mg/kg PO, SC, IM q12h <sup><a href="#">28</a></sup>                                          |                                                                                                      |
| Enrofloxacin (Baytril, Bayer)                                                | 2.5-5 mg/kg PO, IM q12h <sup><a href="#">32</a></sup>                                               | Avoid IM administration                                                                              |
|                                                                              | 5-10 mg/kg PO, SC, IM q12h <sup><a href="#">10,35</a></sup>                                         | Dilute if administering SC                                                                           |
| Erythromycin                                                                 | 10 mg/kg PO, IM q12h <sup><a href="#">12,14</a></sup>                                               | Penicillin-resistant gram-positive cocci; <i>Mycoplasma</i> ; <i>Pasteurella</i> ; <i>Bordetella</i> |
| Gentamicin                                                                   | 2 mg/kg SC, IM q8h <sup><a href="#">10</a></sup>                                                    | Rarely indicated; best to avoid; nephrotoxic                                                         |
| Gentamicin ophthalmic drops                                                  | Topical to cornea or conjunctiva <sup><a href="#">24</a></sup> q8h <sup><a href="#">18</a></sup>    | Corneal abrasions or conjunctivitis; use as in dog or cat                                            |
| Metronidazole                                                                | 20 mg/kg PO q12h <sup><a href="#">24,28</a></sup>                                                   | Anaerobes                                                                                            |
| Mupirocin (2%) (Muricin, Dechra)                                             | Topical to cutaneous lesions q12-24h prn <sup><a href="#">24</a></sup>                              | Bacterial dermatitis or traumatic skin lesions                                                       |
| Neomycin, polymyxin B, bacitracin ophthalmic ointment                        | Topical to cornea or conjunctiva <sup><a href="#">24</a></sup> q8-12h <sup><a href="#">18</a></sup> | Corneal abrasions or conjunctivitis; use as in dog or cat                                            |
| Neomycin, thiabendazole, dexamethasone solution (Tresaderm, Merial)          | Topical to cutaneous lesions or ear canal q12h prn <sup><a href="#">24</a></sup>                    | Bacterial/mycotic dermatitis; otitis externa; antiinflammatory                                       |
| Nystatin, neomycin, thioestrepton, triamcinolone cream (Panalog, Fort Dodge) | Topical to cutaneous lesions q12-24h prn <sup><a href="#">24</a></sup>                              | Bacterial/mycotic dermatitis; antiinflammatory                                                       |
| Oxytetracycline                                                              | 25-50 mg/kg PO q24h × 5-7 days <sup><a href="#">7,8,24</a></sup>                                    | <i>Bordetella</i> ; may be administered in food                                                      |
| Oxytetracycline ophthalmic ointment (Terramycin, Pfizer)                     | Topical to cornea or conjunctiva <sup><a href="#">24</a></sup> q8-12h <sup><a href="#">18</a></sup> | Corneal abrasions or conjunctivitis; use as in dog or cat                                            |
| Penicillin G                                                                 | 40,000 U/kg SC, IM q24h <sup><a href="#">12,28</a></sup>                                            |                                                                                                      |
| Piperacillin                                                                 | 10 mg/kg SC q8-12h <sup><a href="#">24</a></sup>                                                    |                                                                                                      |
| Spiramycin                                                                   | 15 mg/kg PO × 8 days <sup><a href="#">12</a></sup>                                                  | Gingivitis; frequency not listed; not available in the United States                                 |
|                                                                              | 2-20 mg/kg PO, SC,                                                                                  |                                                                                                      |

|                         |                                                              |                                                                                             |
|-------------------------|--------------------------------------------------------------|---------------------------------------------------------------------------------------------|
| Sulfadimethoxine        | IM q24h <sup><a href="#">10,12</a></sup>                     | May have slight nephrotoxicity <sup><a href="#">18</a></sup>                                |
| Trimethoprim/sulfa      | 30 mg/kg PO, SC,<br>IM q12h <sup><a href="#">10,32</a></sup> | Respiratory infections;<br>trimethoprim/sulfamethoxazole is available in<br>injectable form |
| Tylosin (Tylan, Elanco) | 10 mg/kg PO, SC<br>q12h <sup><a href="#">14</a></sup>        | <i>Mycoplasma</i> ; <i>Clostridium</i> ; do not administer<br>IM (causes muscle necrosis)   |

TABLE 7-2 Antifungal Agents Used in Hedgehogs.

| Agent                                         | Dosage                                                                                       | Comments                                 |
|-----------------------------------------------|----------------------------------------------------------------------------------------------|------------------------------------------|
| Chlorhexidine                                 | 2-3% shampoo <sup><a href="#">24</a></sup>                                                   | Dermatophytosis                          |
| Enilconazole (Imaverol, Janssen)              | Topical q24h <sup><a href="#">37</a></sup>                                                   | Dermatophytosis; dilute 1:50             |
| Griseofulvin (microsize)                      | —                                                                                            | Skin and deep mycoses; long-term therapy |
|                                               | 25 mg/kg PO q12h <sup><a href="#">12</a></sup>                                               |                                          |
|                                               | 50 mg/kg PO q24h <sup><a href="#">12,35</a></sup> × 14-21 days <sup><a href="#">26</a></sup> |                                          |
| Iodine tincture 2%                            | Topical <sup><a href="#">18</a></sup>                                                        | Dermatophytosis                          |
| Itraconazole (Sporanox, Ortho McNeil Janssen) | 5-10 mg/kg PO q12-24h <sup><a href="#">24</a></sup>                                          | Systemic mycoses                         |
| Ketoconazole                                  | 10 mg/kg PO q24h × 6-8 wk <sup><a href="#">12,35</a></sup>                                   | Mycoses; use long term                   |
| Lime sulfur                                   | Topical <sup><a href="#">9</a></sup>                                                         | Dermatophytosis                          |
| Nystatin                                      | 30,000 U/kg PO q8-24h <sup><a href="#">24</a></sup>                                          | Yeast infections                         |

TABLE 7-3 Antiparasitic Agents Used in Hedgehogs.

| Agent                              | Dosage                                                             | Comments                                                                           |
|------------------------------------|--------------------------------------------------------------------|------------------------------------------------------------------------------------|
| Amitraz (Mitaban, Pfizer)          | 0.3% topical q7d × 2-3 treatments <sup><a href="#">22,24</a></sup> | Mites ( <i>Caparinia</i> , <i>Chorioptes</i> , etc.); may dilute; use with caution |
| Fenbendazole                       | 10-15 mg/kg PO q14d × 2-3 treatments <sup><a href="#">35</a></sup> | Nematodes                                                                          |
|                                    | 10-30 mg/kg PO q24h × 5 days <sup><a href="#">14</a></sup>         | Nematodes (i.e., <i>Crenosoma</i> , <i>Capillaria</i> )                            |
|                                    | 25 mg/kg PO q10d <sup><a href="#">24</a></sup>                     | Nematodes                                                                          |
| Fipronil spray (Frontline, Merial) | Topical, repeat in 10 days <sup><a href="#">18,21</a></sup>        | Mites; apply 1 spray over dorsum                                                   |
| Flea products                      |                                                                    |                                                                                    |

|                                 |                                                                                                          |                                                                                                                                                |
|---------------------------------|----------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------|
| (feline)                        | Topical <sup>9</sup>                                                                                     | Use sparingly                                                                                                                                  |
| Imidacloprid                    | ½ puppy/kitten dose topical q30d <sup>8</sup>                                                            | Fleas; apply to quilled areas behind head                                                                                                      |
| Ivermectin                      | 0.2 mg/kg PO, SC q14d × 3 treatments <sup>35</sup>                                                       | Mites ( <i>Caparinia</i> , etc.); nematodes; a pyrethrin-based shampoo q7d × several treatments is often needed concurrently for full response |
|                                 | 0.2-0.4 mg/kg PO, SC q10-14d × 3-5 treatments <sup>13,28</sup>                                           | Ectoparasites                                                                                                                                  |
|                                 | 0.5 mg/kg PO, SC q14d × 3 treatments <sup>3</sup>                                                        | Mites; resistance to the lower doses of ivermectin has been noted                                                                              |
|                                 | <1 mg/kg <sup>18</sup> PO, SC                                                                            | For resistant <i>Chorioptes</i>                                                                                                                |
| Levamisole (1%)                 | 10 mg/kg SC, <sup>7</sup> repeat q48h; repeat prn q14d <sup>12</sup>                                     | Nematodes, including lungworms                                                                                                                 |
| Lufenuron                       | ½ puppy/kitten dose PO q30d <sup>8</sup>                                                                 | Fleas                                                                                                                                          |
| Mebendazole                     | 15 mg/kg PO, repeat q14d <sup>18</sup>                                                                   | Nematodes; do not use in animals with hepatic disease                                                                                          |
|                                 | 25 mg/animal <500g q12h; 50 mg/animal >500 g q24h PO × 5 days, repeat q14-21d <sup>18</sup>              | <i>Capillaria</i> , <i>Crenosoma</i> , <i>Brachylaernus</i> , <i>Hymenolepsis</i> , <i>Physaloptera</i>                                        |
| Metronidazole                   | 25 mg/kg PO q12h × 5 days <sup>9,35</sup>                                                                | Intestinal protozoa                                                                                                                            |
| Permethrin (1%)                 | Topical <sup>36</sup>                                                                                    | Mites; apply once via fine mist; change bedding                                                                                                |
| Praziquantel (Droncit, Bayer)   | 7 mg/kg PO, SC, repeat q14d <sup>9,35</sup>                                                              | Cestodes, trematodes                                                                                                                           |
| Selamectin (Revolution, Pfizer) | 6 mg/kg topically <sup>5</sup>                                                                           | Ectoparasites; higher dose may be required                                                                                                     |
| Sulfadimethoxine                | 2-20 mg/kg PO, <sup>12</sup> SC, IM <sup>14</sup> q24h × 2-5 days, off 5 days, on 2-5 days <sup>12</sup> | Coccidia                                                                                                                                       |
|                                 | 10 mg/kg PO q24h × 5-7 days <sup>24</sup>                                                                | Coccidia                                                                                                                                       |
| Sulfadimidine                   | 100-200 mg/kg SC q24h × 3 days <sup>7</sup>                                                              | Coccidia                                                                                                                                       |

TABLE 7-4 Chemical Restraint/Anesthetic Agents Used in Hedgehogs.

| Agent        | Dosage                              | Comments                                                                                         |
|--------------|-------------------------------------|--------------------------------------------------------------------------------------------------|
| Acepromazine | 0.1-1 mg/kg PO, SC, IM <sup>8</sup> | Sedative; hypotension may occur when used alone; atropine pretreatment may alleviate this effect |
| Atipamezole  | 0.3-0.5 mg/kg                       |                                                                                                  |

|                                                      |                                                     |                                                                                                                                                                                                                                 |
|------------------------------------------------------|-----------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| (Antisedan, Pfizer)                                  | IM <sup>37</sup>                                    | Reversal of medetomidine and dexmedetomidine                                                                                                                                                                                    |
|                                                      | 1 mg/kg SC, IM, IV, IP <sup>1,18</sup>              |                                                                                                                                                                                                                                 |
| Atropine                                             | 0.01-0.04 mg/kg SC, IM <sup>28</sup>                | Preanesthetic                                                                                                                                                                                                                   |
| Buprenorphine                                        | —                                                   | See midazolam for combination                                                                                                                                                                                                   |
| Butorphanol                                          | —                                                   | See midazolam for combination                                                                                                                                                                                                   |
| Dexmedetomidine <sup>a</sup><br>(Dexdomitor, Pfizer) | —                                                   | See medetomidine <sup>a</sup>                                                                                                                                                                                                   |
| Diazepam                                             | —                                                   | Diazepam combination follows                                                                                                                                                                                                    |
|                                                      | 0.5-2 mg/kg IM <sup>32</sup>                        | Mild sedation; may be given with ketamine for anesthesia; seizures; midazolam preferred for IM use                                                                                                                              |
| Diazepam (D)/ketamine (K)                            | (D) 0.5-2 mg/kg + (K)<br>5-20 mg/kg IM <sup>3</sup> | Anesthesia; do not use in neck area where there is brown fat; <sup>11</sup> midazolam preferred for IM use                                                                                                                      |
| Enflurane                                            | To effect <sup>28</sup>                             | Anesthesia; not commonly used; isoflurane or sevoflurane preferred                                                                                                                                                              |
| Fentanyl                                             | —                                                   | See medetomidine for combination                                                                                                                                                                                                |
| Hydromorphone                                        | 0.1 mg/kg SC <sup>31</sup>                          | Preoperative anesthesia                                                                                                                                                                                                         |
| Isoflurane                                           | 3-5% induction <sup>35</sup>                        | Anesthetic of choice; generally occurs in an induction chamber or mask                                                                                                                                                          |
|                                                      | 0.5-3% maintenance <sup>34,35</sup>                 | By mask or endotracheal tube                                                                                                                                                                                                    |
| Ketamine                                             | —                                                   | See diazepam and medetomidine for combinations                                                                                                                                                                                  |
|                                                      | 5-20 mg/kg IM <sup>32</sup>                         | Sedation; anesthesia; do not use in neck area where there is brown fat; <sup>14</sup> may use in combination with midazolam (or less preferably diazepam) or an $\alpha_2$ agonist; recovery may be prolonged and/or rough      |
| Ketamine (K)/medetomidine (M)                        | (K) 5 mg/kg + (M) 0.1 mg/kg IM <sup>28,37</sup>     | Anesthesia; (M) reverse with atipamezole (0.3-0.5 mg/kg IM); see medetomidine <sup>a</sup>                                                                                                                                      |
| Medetomidine (Domitor, Pfizer)                       | —                                                   | Medetomidine <sup>a</sup> combinations follow; not commercially available, but can be obtained through select compounding pharmacies; recommend equal volume of dexmedetomidine, but no reports of safety or efficacy available |
|                                                      | 0.05-0.1 mg/kg IM <sup>24,37</sup>                  | Light sedation; reverse with atipamezole (0.3-0.5 mg/kg IM)                                                                                                                                                                     |
|                                                      |                                                     |                                                                                                                                                                                                                                 |

|                                            |                                                             |                                                                                                                                                              |
|--------------------------------------------|-------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                                            | 0.2 mg/kg SC, IM <sup>2</sup>                               | Heavy sedation; reverse with atipamezole (0.3-0.5 mg/kg IM)                                                                                                  |
| Medetomidine (M)/ketamine (K)/fentanyl (F) | (M) 0.2 mg/kg + (K) 2 mg/kg + (F) 0.1 mg/kg SC <sup>1</sup> | Anesthesia; good muscle relaxation; (M) reversed with atipamezole (1 mg/kg IM) and (F) reversed with naloxone (0.16 mg/kg IM); see medetomidine <sup>a</sup> |
| Midazolam                                  | —                                                           | Midazolam combinations follow; it is the preferred benzodiazepine for IM use                                                                                 |
|                                            | 0.25-0.5 mg/kg IM <sup>20</sup>                             | Preanesthetic                                                                                                                                                |
| Midazolam (Mi)/buprenorphine (Bup)         | (Mi) 0.25-0.5 mg/kg + (Bup) 0.03 mg/kg IM <sup>20</sup>     | Painful or stressful procedures                                                                                                                              |
| Midazolam (Mi)/butorphanol (But)           | (Mi) 0.25-0.5 mg/kg + (But) 0.4 mg/kg IM <sup>20</sup>      | Painful or stressful procedures                                                                                                                              |
| Naloxone                                   | 0.1-0.16 mg/kg SC, IM q6-8h <sup>1,18</sup>                 | Reversal of fentanyl                                                                                                                                         |
| Sevoflurane (SevoFlo, Abbott)              | To effect <sup>28</sup>                                     | Anesthesia                                                                                                                                                   |
| Tiletamine/zolazepam (Telazol, Fort Dodge) | 1-5 mg/kg IM <sup>35</sup>                                  | Sedation; anesthesia; recovery may be prolonged and/or rough; rarely indicated because gas anesthesia is preferred                                           |
| Xylazine                                   | 0.5-1 mg/kg IM <sup>32</sup>                                | Anesthesia; may be given with ketamine; rarely indicated because gas anesthesia is preferred                                                                 |
| Yohimbine                                  | 0.5-1 mg/kg IM <sup>28</sup>                                | Reversal of xylazine                                                                                                                                         |

<sup>a</sup> Dexmedetomidine (0.5 mg/mL) is an  $\alpha$ -2 agonist that is the active optical enantiomer of racemic compound medetomidine; ½ the dose of medetomidine (1 mg/mL) but same volume; although the same effects would be expected as with medetomidine (not commercially available, but can be obtained through various compounding services), there is no data on the efficacy and safety of dexmedetomidine in hedgehogs, and, to date, appears to have been seldom used clinically in this species; the effects of the v/v use of the two drugs may not be equivalent, so the dose of dexmedetomidine may need to be adjusted based on clinical response.

TABLE 7-5 Analgesic Agents Used in Hedgehogs.

| Agent | Dosage | Comments |
|-------|--------|----------|
|-------|--------|----------|

|                                                |                                                                               |                                                                                              |
|------------------------------------------------|-------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------|
| Buprenorphine                                  | 0.01 mg/kg SC, IM q6-8h <sup>7,34,37</sup>                                    | Analgesia; higher dose will likely be required                                               |
|                                                | 0.01-0.5 mg/kg SC, IM q8-12h <sup>15</sup>                                    | Analgesia                                                                                    |
| Butorphanol                                    | 0.05 mg/kg q8h SC prn <sup>14</sup>                                           | Analgesia                                                                                    |
|                                                | 0.05-0.1 mg/kg SC, IM q8-12h <sup>15</sup>                                    | Analgesia                                                                                    |
|                                                | 0.2-0.4 mg/kg SC, IM q6-8h <sup>34,35</sup>                                   | Analgesia                                                                                    |
| Carprofen                                      | 1 mg/kg PO, SC q12-24h <sup>18</sup>                                          | Nonsteroidal, antiinflammatory                                                               |
| Dexamethasone                                  | 0.1-1.5 mg/kg IM <sup>12</sup>                                                | Glucocorticoid; inflammation; allergies                                                      |
|                                                | 1-4 mg/kg SC, IM, IV <sup>8,24</sup>                                          | Shock; spinal trauma                                                                         |
| Flunixin meglumine (Banamine, Schering-Plough) | 0.3 mg/kg SC q24h <sup>15</sup>                                               | Nonsteroidal, antiinflammatory; arthritis; chronic inflammation; higher dose may be required |
| Meloxicam (Metacam, Boehringer Ingelheim)      | 0.08 mg/kg PO q24h <sup>31</sup><br>0.2 mg/kg PO, SC q24h <sup>17,18,38</sup> | Nonsteroidal, antiinflammatory                                                               |
| Methylprednisolone                             | 1-2 mg/kg SC <sup>24</sup>                                                    | Glucocorticoid; antiinflammatory                                                             |
| Naloxone                                       | 0.1-0.16 mg/kg SC, IM q6-8h <sup>1,18</sup>                                   | Reversal of fentanyl                                                                         |
| Prednisolone                                   | 2.5 mg/kg PO, SC, IM q12h prn <sup>12,28</sup>                                | Glucocorticoid; allergies                                                                    |
|                                                | 10 mg/kg SC, IM <sup>8,12</sup>                                               | Shock; spinal trauma                                                                         |
| Triamcinolone                                  | 0.2 mg/kg SC, IM <sup>8</sup>                                                 | Glucocorticoid; antiinflammatory; no frequency given                                         |

TABLE 7-6 Miscellaneous Agents Used in Hedgehogs.

| Agent              | Dosage                                               | Comments                         |
|--------------------|------------------------------------------------------|----------------------------------|
| Aluminum hydroxide | 100 mg/kg PO with each syringe feeding <sup>29</sup> | Renal failure; hyperphosphatemia |
|                    |                                                      |                                  |



|                                  |                                                  |                                                               |
|----------------------------------|--------------------------------------------------|---------------------------------------------------------------|
| Atropine                         | 0.05-0.2 mg/kg SC <sup>8</sup>                   | Bradycardia                                                   |
| Bupivacaine                      | 1.1 mg/kg diluted with saline 1:12 <sup>31</sup> | Surgical site infiltration                                    |
| Calcium gluconate (10%)          | 0.5 mg/kg IM <sup>12</sup>                       | Fracture repair                                               |
|                                  | 50 mg/kg IM <sup>24</sup>                        | Hypocalcemia                                                  |
| Calcium gluconate (23%)          | 100-150 mg/kg IV <sup>20</sup>                   |                                                               |
| Carnivore Care (Oxbow)           | 2-3 mL PO <sup>17</sup>                          | Gavage feed; may require slight sedation                      |
| Cimetidine                       | 10 mg/kg PO q8h <sup>24</sup>                    | Treatment of gastric ulcers                                   |
| Doxapram                         | 2-10 mg/kg IV, IP <sup>8,20</sup>                | Respiratory stimulant                                         |
| Enalapril (Enacard, Merial)      | 0.5 mg/kg PO q24h <sup>24</sup>                  | Vasodilator; heart failure                                    |
| Epinephrine                      | 0.003 mg/kg IV <sup>20</sup>                     | Cardiac arrest                                                |
| Erythropoietin (Epogen, Amgen)   | 100 U/kg SC q48-72h <sup>24</sup>                | Chronic anemia                                                |
| Famotidine                       | 1 mg/kg SC q24h <sup>29</sup>                    | Prevention or treatment of gastric ulcers                     |
| Furosemide                       | 2.5-5 mg/kg PO, SC, IM q8h <sup>28,37</sup>      | Edema; diuretic                                               |
| Glycopyrrolate                   | 0.01-0.02 mg/kg SC <sup>8</sup>                  | Bradycardia                                                   |
| Hetastarch                       | 5 mL/kg IV <sup>20</sup>                         | Give over 5-10 min                                            |
| Hyaluronidase                    | 100-150 U/L <sup>24</sup>                        | Add to SC fluids; facilitates fluid absorption                |
| Iron dextran                     | 25 mg/kg IM <sup>37</sup>                        | Anemia                                                        |
| Lactated Ringer's solution (LRS) | —<br>1-15 mL/kg IV <sup>20</sup>                 | Fluid replacement; dehydration; shock                         |
|                                  | 25 mL/kg SC q12h <sup>38</sup>                   |                                                               |
|                                  | 50-100 mL/kg/d <sup>17</sup>                     |                                                               |
| Lactobacilli                     | 2.5 mL/kg q24h <sup>12</sup>                     | May aid in restoring gastrointestinal flora                   |
| Lactulose                        | 0.3 mL/kg PO q8-12h <sup>24</sup>                | Hepatic disease; constipation <sup>18</sup>                   |
| Metoclopramide                   | 0.2-0.5 mg/kg PO, SC <sup>24</sup>               | Regurgitation; antiemetic; GI motility enhancer <sup>18</sup> |
| Sucralfate (Carafate, Axcan)     | 10 mg/kg PO q8-12h <sup>28</sup>                 | Gastrointestinal ulcers                                       |
| Theophylline                     | 10 mg/kg PO, IM q12h <sup>24</sup>               | Bronchodilator                                                |
|                                  |                                                  |                                                               |



|                    |                                                  |                                                                                                                        |
|--------------------|--------------------------------------------------|------------------------------------------------------------------------------------------------------------------------|
| Vitamin A          | 400 U/kg IM q24h × 10 days <sup>12</sup>         | Skin disorders; excessive quill loss                                                                                   |
| Vitamin B complex  | 1 mL/kg SC, IM once <sup>14,28</sup>             | CNS signs; paralysis of unknown origin; anorexia; use small animal formulation                                         |
| Vitamin C          | 50-200 mg/kg PO, SC q24h <sup>12</sup>           | Deficiency; infections; gingivitis                                                                                     |
|                    | 1 g ascorbic acid/L drinking water <sup>12</sup> | Change daily; not recommended; alternative routes of supplementation preferred; use oral pills or powder <sup>18</sup> |
| Vitamins, multiple | <1 drop/kg PO q24h <sup>5</sup>                  | Subclinical deficiency; hand-rearing orphans                                                                           |

TABLE 7-7 Hematologic and Serum Biochemical Values of Hedgehogs.<sup>11</sup>

| Measurement                       | Reference Range      |
|-----------------------------------|----------------------|
| <b>Hematology</b>                 |                      |
| PCV (%)                           | 36 ± 7 (22-64)       |
| RBC (10 <sup>6</sup> /μL)         | 6 ± 2 (3-16)         |
| Hgb (g/dL)                        | 12 ± 2.8 (7-21.1)    |
| MCV (fL)                          | 67 ± 9 (41-94)       |
| MCH (pg)                          | 22 ± 4 (11-31)       |
| MCHC (g/dL)                       | 34 ± 5 (17-48)       |
| Platelets (10 <sup>3</sup> /μL)   | 226 ± 108 (60-347)   |
| WBC (10 <sup>3</sup> /μL)         | 11 ± 6 (3-43)        |
| Neutrophils (10 <sup>3</sup> /μL) | 5.1 ± 5.2 (0.6-37.4) |
| Lymphocytes (10 <sup>3</sup> /μL) | 4 ± 2.2 (0.9-13.1)   |
| Monocytes (10 <sup>3</sup> /μL)   | 0.3 ± 0.3 (0-1.6)    |
| Eosinophils (10 <sup>3</sup> /μL) | 1.2 ± 0.9 (0-5.1)    |
| Basophils (10 <sup>3</sup> /μL)   | 0.4 ± 0.3 (0-1.5)    |
| <b>Chemistries</b>                |                      |
| ALP (U/L)                         | 51 ± 21 (8-92)       |
| ALT (U/L)                         | 53 ± 24 (16-134)     |
| Amylase (U/L)                     | 510 ± 170 (244-858)  |
| AST (U/L)                         | 34 ± 22 (8-137)      |
| Bilirubin, total (mg/dL)          | 0.3 ± 0.3 (0-1.3)    |
| BUN (mg/dL)                       | 27 ± 9 (13-54)       |
| Calcium (mg/dL)                   | 8.8 ± 1.4 (5.2-11.3) |
| Chloride (mEq/L)                  | 109 ± 10 (92-128)    |
| Cholesterol (mg/dL)               | 131 ± 25 (86-189)    |

|                       |                      |
|-----------------------|----------------------|
| Creatine kinase (U/L) | 863 ± 413 (333-1964) |
| Creatinine (mg/dL)    | 0.4 ± 0.2 (0-0.8)    |
| GGT (U/L)             | 4 ± 1 (0-12)         |
| Glucose (mg/dL)       | 89 ± 30              |
| LDH (U/L)             | 441 ± 258 (57-820)   |
| Phosphorus (mg/dL)    | 5.3 ± 1.9 (2.4-12)   |
| Potassium (mEq/L)     | 4.9 ± 1 (3.2-7.2)    |
| Protein, total (g/dL) | 5.8 ± 0.7 (4-7.7)    |
| Albumin (g/dL)        | 2.9 ± 0.4 (1.8-4.2)  |
| Globulin (g/dL)       | 2.7 ± 0.5 (1.6-3.9)  |
| Sodium (mEq/L)        | 141 ± 9 (120-165)    |
| Triglycerides (mg/dL) | 38 ± 22 (10-96)      |

TABLE 7-8 Biologic and Physiologic Values of Hedgehogs.
 [5,8,13,19,27,30,33,35,39](#)

| Parameter                           | Biologic and Physiologic Values                             |
|-------------------------------------|-------------------------------------------------------------|
| Weight                              | Male, 400-600 g                                             |
|                                     | Female, 300-400 g                                           |
| Life span                           | Avg 4-6 years, may live 8 years                             |
| Temperature, rectal                 | 95.7-98.6°F (35.4-37°C)                                     |
| Preferred environmental temperature | 75-85°F (24-29°C)                                           |
|                                     | Temps <60°F (16°C) induce torpor state                      |
| Adult dental formula                | 2 (I3/2:C1/1:P3/2:M3/3) = 36; variations have been noted    |
| Gastrointestinal system             | Simple stomach; no cecum; transit time 12-16 hours          |
| Heart rate                          | 180-280 beats/min                                           |
| Respiratory rate                    | 25-50 breaths/min                                           |
| Age at sexual maturity              | Male, 6-8 months                                            |
|                                     | Female, 2-6 months                                          |
| Reproductive life span              | Male, throughout life                                       |
|                                     | Female, 2-3 years                                           |
| Gestation                           | 34-37 days                                                  |
| Milk composition                    | Protein, 16 g/100 g; carbohydrate, trace; fat, 25.5 g/100 g |
| Litter size                         | Avg 3-4 (range 1-7)                                         |
| Birth weight                        | 10-18 g                                                     |
| Eyes open                           | 14-18 days                                                  |
| Deciduous teeth eruption            | Begins on day 18; all deciduous teeth erupt by 9 weeks      |
| Permanent teeth eruption            | Begins at 7-9 weeks                                         |
|                                     |                                                             |

TABLE 7-9 Suggested Diets for Hedgehogs.[6](#),[13](#),[14](#),[18](#),[30](#),[32](#)

|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <p>The natural diet of hedgehogs includes insects, worms, snails, slugs, and, occasionally, small vertebrates and fruit. In captivity, insectivorous mammals are traditionally fed diets that are 30-50% protein and 10-20% fat (dry matter basis). Although scientific studies regarding hedgehog nutritional needs are lacking, commercial diets appear to be the most balanced diet that a pet owner can offer. If hedgehog food is not used, premium food for less active cats should form the basis of the diet. Depending on the animal’s weight and activity, 1-2 Tbs of the main diet is typically fed daily. Growing animals and reproductively active females may be fed the usual diet ad libitum, and calcium-rich foods should be supplemented.</p> |
| <p>In addition to the main diet, 1-2 tsp of varied moist foods (e.g., canned cat or dog food, cooked meat or egg, low-fat cottage cheese) and approximately ½ tsp of fruit (e.g., banana, grape, apple, pear, berries) or vegetables (e.g., beans, cooked carrots, squash, peas, tomatoes, leafy greens) should also be provided daily. One key to balanced nutrition is to provide variety. Acceptable treats include mealworms, earthworms, waxworms, crickets, and cat treats; these may be hidden in the bedding to promote foraging activity.</p>                                                                                                                                                                                                           |
| <p>Do not overfeed hedgehogs because of potential obesity; amounts can be adjusted up or down to meet special nutritional situations (e.g., pregnancy, obesity). Hedgehogs are generally fed once daily in the evening.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| <p><b>Diet 1</b></p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
| <ul style="list-style-type: none"><li>• 1 heaping tsp bird of prey diet or insectivore diet</li><li>• 1.5 heaping tsp high-quality cat food<sup>a</sup></li><li>• 1 heaping tsp fruit/vegetable mix<sup>b</sup></li><li>• 6-10 small mealworms or 1-2 crickets (more if pregnant or lactating)<sup>c</sup></li></ul>                                                                                                                                                                                                                                                                                                                                                                                                                                             |
| <p><b>Diet 2</b></p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
| <ul style="list-style-type: none"><li>• 3 heaping tsp high-quality, low-calorie cat food<sup>a</sup></li><li>• 1 heaping tsp fruit/vegetable mix<sup>b</sup></li><li>• 6 small mealworms or 1-2 crickets<sup>c</sup></li></ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
| <p><b>Diet 3</b></p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
| <ul style="list-style-type: none"><li>• 3-4 tsp commercial insectivore diet</li><li>• 5-6 small mealworms or 1-2 crickets<sup>c</sup></li></ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |

- <sup>a</sup> Young or pregnant/lactating hedgehogs can use kitten or ferret formulations; adults may use “lite” adult cat foods.
- <sup>b</sup> Fruit/vegetable mix: chop together ½ tsp diced leafy dark greens (spinach, kale, leaf lettuce), ¼ tsp diced carrot, ¼ tsp diced apple, ¼ tsp diced banana, ¼ tsp diced grape or raisin, ¼ tsp vitamin/mineral powder (Vionate or crushed feline vitamin tab).
- <sup>c</sup> Mealworms are high calorie, low calcium and should be limited to 2-3 times a week; crickets can be fed insectivore diet plus some of the fruit/vegetable mixture for a minimum of 3 days after purchase before being fed to the hedgehog; other types of commercially available insects can also be fed.

TABLE 7-10 Hand-Rearing Orphaned Hedgehogs.[13,30,33](#)

|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1. Leave neonates with mother if possible for first 24-72 hr for colostrum ingestion.                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
| 2. In cases of lactation failure or abandonment by the female, fostering the pups to another dam with similarly aged pups is generally successful.                                                                                                                                                                                                                                                                                                                                                                                                       |
| 3. Feed a canine milk replacer with added lactase (Lactaid, McNeil Nutritionals) using a 1 cc syringe with a catheter tip or an eye dropper.                                                                                                                                                                                                                                                                                                                                                                                                             |
| 4. Neonates should be fed as much as they will consume every 2-4 hours for about 3 weeks, then the time between feedings can be gradually lengthened; the newborns should gain 1-2 g/day during the first week, about 3-4 g/day during the second week, 4-5 g/day during the third and fourth weeks, and 7-9 g/day until they are 60 days old; at 4-6 weeks, parent- or hand-raised young should be weaned by offering canned dog or cat food, minced beef, or freshly molted mealworms; hand-rearing hedgehogs is often associated with high mortality. |
| 5. The ambient temperature should be maintained at 90-95°F (32-35°C) for the first few weeks.                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
| 6. Manual stimulation is required for defecation and should be performed after each meal by massaging the ventrum and perineal area with a cloth or swab moistened in warm water.                                                                                                                                                                                                                                                                                                                                                                        |

TABLE 7-11 Common Injection and Venipunctures Sites in Hedgehogs.[5,16,17,25](#)

| Injection sites | Comments                                                                          |
|-----------------|-----------------------------------------------------------------------------------|
|                 | 5-10 mL/site; flank at junction of furred skin and spined mantle; SC under mantle |

|                    |                                                                                                         |
|--------------------|---------------------------------------------------------------------------------------------------------|
| Subcutaneous       | requires 1.5 to 3 inch needle                                                                           |
| Intramuscular      | 0.5 mL/site; anterior thigh, triceps; may require sedation; orbicularis up to 1 mL/site                 |
| Intravenous        | Lateral saphenous, jugular                                                                              |
| Intraperitoneal    | 5-10 mL; requires sedation for access; caudal right abdominal quadrant; useful for fluid administration |
| Intraosseous       | 0.5-1 mL slow bolus; requires anesthesia for tibial placement; rarely used                              |
| Venipuncture sites | Comments                                                                                                |
| Saphenous          | 0.5-1 mL; requires sedation                                                                             |
| Jugular            | 0.5-1 mL; requires sedation; easier in thin animals; not visible or palpable; blind stick               |
| Cephalic           | Requires sedation                                                                                       |
| Cranial vena cava  | Requires sedation; risk of cardiac puncture                                                             |

TABLE 7-12 Preventive Medicine in Hedgehogs.<sup>16</sup>

|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <ul style="list-style-type: none"> <li>• Prevent obesity; have owners weigh hedgies at least monthly</li> <li>• Dental prophylaxis—routine brushing, scaling</li> <li>• Nails need periodic trimming</li> <li>• Annual (or semi-annual) physical examination, including fecal flotation and direct smear</li> <li>• No routine vaccines recommended</li> <li>• Prevent chilling; provide heated environment with dry bedding</li> <li>• Microchip for personal identification</li> </ul> |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|

TABLE 7-13 Common Diseases in Hedgehogs.<sup>5,8,18</sup>

|                                                                                                                                                                                                                                                                                                        |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <ul style="list-style-type: none"> <li>• Obesity</li> <li>• Dental (gingivitis, periodontitis)</li> <li>• Neoplasia (high tumor rate in animals &gt;3 yr; usually malignant; most common: mammary tumors, lymphosarcoma, oral squamous cell carcinoma)</li> <li>• Salmonellosis<sup>a</sup></li> </ul> |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|

- Trauma
- Dermatitis (chorioptic mange mites, bacteria, dermatophytosis<sup>a</sup>)
- Fatty liver, hepatitis
- Pneumonia
- Intestinal parasites
- Heart disease
- Neurologic disease (wobbly hedgehog syndrome)
- Otitis externa
- Ocular proptosis
- Renal disease (urolithiasis, renal calculi, cystitis, etc.)

<sup>a</sup> Zoonotic.

TABLE 7-14 Common Vocalizations in Hedgehogs.<sup>8</sup>

|                                    |                                                                                                                                                                                                                       |
|------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Snorting/huffing; hissing/grunting | Aggressive or warning sounds produced by sharp vibrating exhalations through the nostrils; generally made when the animal is disturbed, when it encounters another animal, or when it is in the process of rolling up |
| Screaming                          | Severe distress call given when the animal is in distress or pain                                                                                                                                                     |
| Twittering/whistling               | High-pitched sounds of neonates; whistling stimulates contact by the dam                                                                                                                                              |
| Clucking                           | High-pitched contact call of the dam to neonates; also made by courting males                                                                                                                                         |
| Snuffling                          | Made as hedgehogs search for food                                                                                                                                                                                     |
| Inaudible sounds                   | Hedgehogs can make and hear sounds in the 40- to 90-kHz range, above the range of human hearing                                                                                                                       |

TABLE 7-15 Cardiac Measurements in Hedgehogs.<sup>a,4</sup>

| Radiographic Measurements <sup>b</sup> | Mean ± SD (Range)       |
|----------------------------------------|-------------------------|
| AB/CD                                  | 1.38 ± 0.11 (1.24-1.59) |
| AB/H                                   | 0.88 ± 0.07 (0.74-1.01) |
| AB/R5-7                                | 1.89 ± 0.29 (1.55-2.73) |
| CD/H                                   | 0.63 ± 0.04 (0.58-0.7)  |
| VHS                                    | 8.16 ± 0.48 (7.25-8.75) |

|                                                   |                             |
|---------------------------------------------------|-----------------------------|
| L/W                                               | 1.4 ± 0.11 (1.16-1.55)      |
| L/C                                               | 1.64 ± 0.25 (1.38-2.13)     |
| W/T                                               | 0.6 ± 0.03 (0.55-0.66)      |
| W/C                                               | 1.17 ± 0.17 (1-1.45)        |
| <b>Echocardiographic Measurements<sup>c</sup></b> | Mean ± SD (Range)           |
| IVSd (cm)                                         | 0.15 ± 0.01 (0.13-0.17)     |
| IVSs (cm)                                         | 0.22 ± 0.02 (0.19-0.24)     |
| LVIDd (cm)                                        | 0.74 ± 0.05 (0.67-0.84)     |
| LVIDs (cm)                                        | 0.58 ± 0.03 (0.54-0.65)     |
| LVFWd (cm)                                        | 0.16 ± 0.01 (0.14-0.18)     |
| LVFWs (cm)                                        | 0.23 ± 0.02 (0.19-0.27)     |
| FS (%)                                            | 21.45 ± 2.5 (17.4-26.8)     |
| EPSS (cm)                                         | 0.11 ± 0.02 (0.09-0.14)     |
| AO (cm)                                           | 0.36 ± 0.02 (0.31-0.4)      |
| LA (cm)                                           | 0.56 ± 0.04 (0.51-0.62)     |
| LA/AO (cm)                                        | 1.55 ± 0.16 (1.37-1.92)     |
| LVOT Vmax (m/sec)                                 | 0.489 ± 0.108 (0.296-0.662) |
| RVOT Vmax (m/sec)                                 | 0.335 ± 0.094 (0.236-0.512) |
| R-wave amplitude (mV)                             | 0.22 ± 0.11 (0.08-0.5)      |
| QRS duration (sec)                                | 0.03 ± 0 (0.03-0.03)        |
| Mean electrical axis                              | -10 ± 13 (-28 to 8)         |
| Heart rate (beats/min)                            | 200 ± 48 (100-260)          |

<sup>a</sup>  $n = 13$ ; 5 male, 8 female; age range 6 mo-5 yr, 7 <1 yr, 6 >1 yr.

<sup>b</sup> *AB*, apicobasilar length of heart; *CD*, maximum width of heart perpendicular to *AB*; *H*, vertical depth of thorax from ventral border of spine to dorsal border of sternum at level of tracheal bifurcation; *R5-7*, distance from 5<sup>th</sup> rib cranial edge to 7<sup>th</sup> rib caudal edge; *VHS*, vertebral heart score; *L*, heart length; *W*, maximum width perpendicular to *L*; *C*, length of clavicle; *T*, thoracic width at level of 6<sup>th</sup> rib articulation with vertebral column.

<sup>c</sup> *IVSd*, interventricular septal thickness in diastole; *IVSs*, interventricular septal thickness in systole; *LVIDd*, left ventricular internal diameter in diastole; *LVIDs*, left ventricular internal diameter in systole; *LVFWd*, left ventricular free wall thickness in diastole; *LVFWs*, left ventricular free wall thickness in systole; *FS*, fractional shortening; *EPSS*, E-point-to-septal separation length; *AO*, aortic

diameter in diastole; *LA*, left atrium internal dimension; *LVOT*, maximum velocity of left ventricular outflow; *RVOT*, maximum velocity of right ventricular outflow.

## References

1. Arnemo JM, Soli NE. Chemical immobilization of free-ranging European hedgehogs (*Erinaceus europaeus*). *J Zoo Wildl Med*. 1995;26:246–251.
2. Barbiere R. Insectivora (hedgehogs, tenrecs, shrews, moles) and Dermoptera (flying lemurs). In: Fowler ME, Miller RE. *Zoo and Wild Animal Medicine*. 5th ed. Philadelphia: WB Saunders Co; 2003:304–315.
3. Bennett RA. Husbandry and medicine of hedgehogs. *Proc Exotic Sm Mam Med Mgt (Annu Conf Assoc Avian Vet)*; 2000:109–114.
4. Black PA, Marshall C, Seyfried AW, et al. Cardiac assessment of African hedgehogs (*Atelerix albiventris*). *J Zoo Wildl Med*. 2011;42:49–53.
5. Carpenter JW. Personal observation; 2011.
6. Crawford RL. Fact sheet. brief introduction to hedgehogs. Beltsville, MD: Animal Welfare Information Center, National Agricultural Library; 1995:1–7.
7. Gregory MW, Stocker L. Hedgehogs. In: Beynon PH, Cooper JE. *BSAVA Manual of Exotic Pets*. Gloucestershire: British Small Animal Veterinary Association; 1991:63–68.
8. Heatley JJ. Hedgehogs. In: Mitchell MA, Tully TN, Jr. *Manual of Exotic Pet Practice*. St Louis: Saunders/Elsevier; 2009:433–455.
9. Hoefer HL. Hedgehogs. *Vet Clin North Am Small Anim Pract*. 1994;24:113–120.
10. Hoefer HL. Clinical approach to the African hedgehog. *Proc North Am Vet Conf*; 1999:836–838.
11. International Species Information System. Apple Valley, MN: International Species Information System; 2002.



12. Isenbügel E, Baumgartner RA. Diseases of the hedgehog. In: Fowler ME, ed. *Zoo and Wild Animal Medicine: Current Therapy 3*. Philadelphia: WB Saunders Co; 1993:294–302.
13. Ivey E, Carpenter JW. African hedgehogs. In: Quesenberry KE, Carpenter JW. *Ferrets, Rabbits, and Rodents: Clinical Medicine and Surgery*. 3rd ed. Philadelphia: Saunders/Elsevier; 2012:411–427.
14. Johnson-Delaney CA. *Exotic Companion Medicine Handbook for Veterinarians*. Lake Worth, FL: Wingers Publ; 1996.
15. Johnson-Delaney CA. Other small mammals. In: Meredith A, Redrobe S. *BSAVA Manual of Exotic Pets*. 4th ed. Quedgeley: British Small Animal Veterinary Association; 2002:102–115.
16. Johnson-Delaney CA. Hedgehogs. In: Johnson-Delaney CA, ed. *Exotic Companion Medicine Handbook for Veterinarians*. Lake Worth, FL: Zoological Education Network, 2005.
17. Johnson-Delaney CA. Common procedures in hedgehogs, prairie dogs, exotic rodents, and companion marsupials. *Vet Clin North Am Exotic Anim Pract*. 2006;9:415–435.
18. Johnson-Delaney CA. What veterinarians need to know about hedgehogs. *Exotic DVM*. 2007;9.1:38–44.
19. Landes E, Zentek J, Wolf P, et al. Investigations on the composition of milk and development of sucklings in hedgehogs. *Kleintierpraxis*. 1997;42:647–658.
20. Lennox AM. Emergency and critical care procedures in sugar gliders (*Petaurus breviceps*), African hedgehogs (*Atelerix albiventris*), and prairie dogs (*Cynomys* spp). *Vet Clin North Am Exotic Anim Pract*. 2007;10:533–555.
21. Leonatti SR. *Ornithonyssus bacoti* mite infestation in an African pygmy hedgehog. *Exotic DVM*. 2007;9.2:3–4.
22. Letcher JD. Amitraz as a treatment for acariasis in African hedgehogs (*Atelerix albiventris*). *J Zoo Anim Med*. 1988;19:24–29.

23. Levine BS. Review of antibiotic-impregnated polymethylmethacrylate beads in avian and exotic pets. *Exotic DVM*. 2003;5.4:11.
24. Lightfoot TL. Therapeutics of African pygmy hedgehogs and prairie dogs. *Vet Clin North Am Exotic Anim Pract*. 2000;3:155–172.
25. Longley L. Anaesthesia of other small mammals. In: Longley L, ed. *Anaesthesia of Exotic Pets*. Philadelphia: Saunders/Elsevier; 2008:96–102.
26. Marshall KL. Fungal diseases in small mammals. therapeutic trends and zoonotic considerations. *Vet Clin North Am Exotic Anim Pract*. 2003;6:415–427.
27. Morgan KR, Berg BM. Body temperature regulation and energy metabolism in pigmy hedgehogs. *Am Zool*. 1997;37:150A.
28. Morrissey JK, Carpenter JW. Formulary. In: Quesenberry KE, Carpenter JW. *Ferrets, Rabbits, and Rodents: Clinical Medicine and Surgery*. 3rd ed. St Louis: Saunders/Elsevier; 2012:566–575.
29. Powers LV. Subcutaneous implantable catheter for fluid administration in an African pygmy hedgehog. *Exotic DVM*. 2002;4.5:16–17.
30. Reeve N. *Hedgehogs*. London: T & AD Poyser Ltd; 1994.
31. Rhody JL, Schiller CA. Spinal osteosarcoma in a hedgehog with pedal self-mutilation. *Vet Clin North Am Exotic Anim Pract*. 2006;9:625–631.
32. Smith AJ. Husbandry and medicine of African hedgehogs (*Atelerix albiventris*). *J Small Exotic Anim Med*. 1992;2:21–28.
33. Smith AJ. Neonatology of the hedgehog (*Atelerix albiventris*). *J Small Exotic Anim Med*. 1995;3:15–18.
34. Smith AJ. Medical management of hedgehogs. Proc 21st Annu Waltham/OSU Symp; 1997:57–61.
35. Smith AJ. General husbandry and medical care of hedgehogs. In: Bonagura JD, ed. *Kirk's Current Veterinary Therapy XIII: Small Animal Practice*.

Philadelphia: WB Saunders Co; 2000:1128–1133.

36. Staley EC, Staley EE, Behr MJ. Use of permethrin as a miticide in the African hedgehog (*Atelerix albiventris*). *Vet Hum Toxicol*. 1994;36:138.

37. Stocker L. *Medication for Use in the Treatment of Hedgehogs*. Ayelsbury: Marshcliff; 1992.

38. Vuolo S, Whittington JK. Dystocia secondary to a perianal fetal hernia in an African hedgehog. *Exotic DVM*. 2008;10.3:10–12.

39. Wrobel D, Brown SA. *The Hedgehog. An Owner's Guide to a Happy, Healthy Pet*. New York: Howell Book House; 1997.

# Chapter 8

## Rodents

Jörg Mayer

TABLE 8-1 Antimicrobial and Antifungal Agents Used in Rodents.<sup>a</sup>

| Agent                                                | Dosage                                                   | Comments                                                                                       |
|------------------------------------------------------|----------------------------------------------------------|------------------------------------------------------------------------------------------------|
| Amikacin                                             | 5 mg/kg SC, IM<br>q8h <sup>40</sup>                      | Chinchillas                                                                                    |
|                                                      | 8-16 mg/kg SC,<br>IM, IV divided<br>q8-24h <sup>10</sup> | All species/also administer fluid therapy                                                      |
|                                                      | 15 mg/kg IM<br>q12h <sup>60</sup>                        | Guinea pigs/high peak dosing regimen as efficacious as<br>divided regimen                      |
| Amoxicillin/clavulanic<br>acid (Clavamox,<br>Pfizer) | 20 mg/kg PO<br>q12h <sup>66</sup>                        | Mice, rats                                                                                     |
| Amphotericin B                                       | 0.1-1 mg/kg IV<br>q24h 5 days/wk<br>× 3 wk <sup>45</sup> | Most species/histoplasmosis                                                                    |
|                                                      | 0.11 mg/kg SC <sup>1</sup>                               | Mice/use with caution; may cause renal toxicity                                                |
|                                                      | 0.43 mg/kg PO <sup>1</sup>                               | Mice/candidiasis                                                                               |
| Ampicillin                                           | —                                                        | Do not use in hamsters, guinea pigs, chinchillas; may cause<br>enterocolitis <sup>1</sup>      |
|                                                      | 6-30 mg/kg PO<br>q8h <sup>3</sup>                        | Gerbils                                                                                        |
|                                                      | 20-100 mg/kg<br>PO, SC, IM<br>q8h <sup>12,66</sup>       | Gerbils, mice, rats                                                                            |
| Azithromycin                                         | 15-30 mg/kg<br>PO q24h <sup>66</sup>                     | Most species                                                                                   |
|                                                      | 35 mg/kg PO<br>q24h <sup>16</sup>                        | Most species                                                                                   |
|                                                      | 75 mg/kg IP<br>q24h × 5 days <sup>30</sup>               | Mice                                                                                           |
| Captan powder<br>(Orthocide, Chevron)                | 1 tsp/2 cups<br>dust <sup>41</sup>                       | Chinchillas/fungicide to prevent spread of dermatophytes<br>between cagemates; add to dust box |
|                                                      |                                                          |                                                                                                |

|                                     |                                             |                                                            |
|-------------------------------------|---------------------------------------------|------------------------------------------------------------|
| Carbenicillin                       | 100 mg/kg PO q12h <sup>3</sup>              | Mice, rats                                                 |
|                                     | 200 mg/kg IP <sup>1</sup>                   | Mice                                                       |
| Cephalexin                          | 15 mg/kg SC q24h <sup>66</sup>              | Rats                                                       |
|                                     | 25 mg/kg SC q24h <sup>66</sup>              | Hamsters, gerbils                                          |
|                                     | 60 mg/kg PO q12h <sup>66</sup>              | Mice                                                       |
| Cephaloridine                       | 10-25 mg/kg SC, IM q24h <sup>3</sup>        | Hamsters, mice, rats                                       |
| Chloramphenicol palmitate           | 30-50 mg/kg PO q8-12h <sup>66</sup>         | Most species                                               |
| Chloramphenicol succinate           | 30-50 mg/kg PO, SC, IM q8-12h <sup>66</sup> | All species                                                |
|                                     | 0.5 mg/mL drinking water <sup>13</sup>      | Mice                                                       |
|                                     | 0.83 mg/mL drinking water <sup>13</sup>     | Gerbils                                                    |
|                                     | 1 mg/mL drinking water <sup>13</sup>        | Guinea pigs                                                |
| Chloramphenicol ophthalmic ointment | Topical to eyes q6-12h <sup>72</sup>        | All species                                                |
| Chlortetracycline                   | 10 mg/kg SC, IM q12h <sup>2,66</sup>        | Rats                                                       |
|                                     | 20 mg/kg PO, SC, IM q12h <sup>2,66</sup>    | Hamsters                                                   |
|                                     | 25 mg/kg PO, SC, IM q12h <sup>2,66</sup>    | Mice                                                       |
|                                     | 50 mg/kg PO q12h <sup>2,66</sup>            | Chinchillas                                                |
| Ciprofloxacin (Cipro, Bayer)        | 5-20 mg/kg PO q12-24h <sup>33,66</sup>      | All species/may cause arthropathies in young               |
|                                     |                                             | Most species/can cause diarrhea; do not give orally; avoid |

|                                     |                                                                                   |                                                                                                                                                                             |
|-------------------------------------|-----------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Clindamycin                         | 7.5 mg/kg SC<br>q12h <sup><a href="#">26</a></sup>                                | or use with caution in chinchillas and guinea pigs; great bone penetration                                                                                                  |
| Doxycycline                         | 2.5-5 mg/kg PO<br>q12h <sup><a href="#">2,33</a></sup>                            | All species/pneumonia; may give in combination with enrofloxacin; do not use in young and pregnant animals                                                                  |
|                                     | 70-100 mg/kg<br>SC, IM q7d <sup><a href="#">65,66</a></sup>                       | Mice, rats/use long-acting formulation                                                                                                                                      |
| Enilconazole                        | Dip in a 0.2%<br>solution q7d <sup><a href="#">1,77</a></sup>                     | Mice/dermatophytosis                                                                                                                                                        |
| Enrofloxacin (Baytril,<br>Bayer)    | —                                                                                 | Very high doses may cause arthropathies in young if given for a prolonged time; limit SC, IM injections; SC injections can be diluted in NaCl or lactated Ringer's solution |
|                                     | 5-20 mg/kg PO,<br>SC, IM<br>q12h <sup><a href="#">1,10,33,66</a></sup>            | Most species/may combine with doxycycline for <i>Mycoplasma</i> in rats                                                                                                     |
|                                     | 0.05-0.2<br>mg/mL<br>drinking water<br>× 14 days <sup><a href="#">33,84</a></sup> | Gerbils, hamsters, mice, rats/pasteurellosis                                                                                                                                |
| Enrofloxacin<br>(E)/doxycycline (D) | 10 mg/kg (E) +<br>5 mg/kg (D) PO<br>q12h <sup><a href="#">71</a></sup>            | Rats/ <i>Mycoplasma</i>                                                                                                                                                     |
| Erythromycin                        | —                                                                                 | Do not use in chinchillas, guinea pigs, hamsters (or use with caution) <sup><a href="#">52</a></sup>                                                                        |
|                                     | 20 mg/kg PO<br>q12h <sup><a href="#">66,86</a></sup>                              | Mice, rats                                                                                                                                                                  |
|                                     | 0.13 mg/mL<br>drinking<br>water <sup><a href="#">1,14</a></sup>                   | Hamsters/outbreaks of proliferative ileitis; use with caution: can cause enterotoxemia; equivalent to 500 mg/gal drinking water                                             |
| Furazolidone                        | 30 mg/kg PO<br>q24h <sup><a href="#">13</a></sup>                                 | Hamsters                                                                                                                                                                    |
|                                     | 5.5 mg/mL<br>drinking<br>water <sup><a href="#">13</a></sup>                      | Guinea pigs                                                                                                                                                                 |
| Gentamicin                          | 2 mg/kg IM<br>q12h <sup><a href="#">1</a></sup>                                   | Chinchillas/bacterial enteritis; <i>Pseudomonas</i>                                                                                                                         |
|                                     | 4-24 mg/kg SC,<br>IM q12h <sup><a href="#">1,33</a></sup>                         | All species                                                                                                                                                                 |
|                                     | 5 mg/kg SC, IM<br>q24h <sup><a href="#">3,13,19</a></sup>                         | All species                                                                                                                                                                 |
|                                     | 20 mg/kg SC<br>q24h <sup><a href="#">1</a></sup>                                  | Rats                                                                                                                                                                        |

|                               |                                                     |                                                                                                         |
|-------------------------------|-----------------------------------------------------|---------------------------------------------------------------------------------------------------------|
|                               | 10 mg/mL drinking water or topical <sup>22</sup>    | Gerbils/nasal dermatitis                                                                                |
| Griseofulvin                  | —                                                   | Dermatophytosis; do not use in pregnant animals; can cause diarrhea, leukopenia, anorexia <sup>33</sup> |
|                               | 15-50 mg/kg PO q24h × 14-28 days <sup>33,72</sup>   | Guinea pigs/doses up to 100 mg/kg have been used                                                        |
|                               | 25 mg/kg PO q24h <sup>40</sup>                      | Chinchillas                                                                                             |
|                               | 1.5% in DMSO topical × 5-7 days <sup>33</sup>       | All species                                                                                             |
|                               | 250 mg/kg q10d × 4 treatments on feed <sup>47</sup> | Prairie dogs                                                                                            |
| Itraconazole                  | 2.5-10 mg/kg PO q24h <sup>1</sup>                   | Rats/vaginal candidiasis; guinea pigs/systemic candidiasis                                              |
|                               | 50-150 mg/kg PO q24h <sup>1</sup>                   | Mice/blastomycosis                                                                                      |
| Ketoconazole                  | 10-40 mg/kg PO q24h × 14 days <sup>1</sup>          | All species/systemic mycoses; candidiasis                                                               |
| Lime sulfur dip               | Dip q7d × 4-6 treatments <sup>3,66</sup>            | All species/dermatophytosis; dilute 1:40 with water                                                     |
| Lufenuron (Program, Novartis) | 100 mg/kg PO q14d × 3 treatments <sup>25</sup>      | Chinchillas, degus/dermatomycoses                                                                       |
| Marbofloxacin                 | 4 mg/kg PO, SC q24h <sup>25</sup>                   | All species/do not give during lactation, pregnancy or while growing; injectable can be given orally    |
| Metronidazole                 | —                                                   | Anaerobes; add sucrose for palatability                                                                 |
|                               | 10-20 mg/kg PO q12h <sup>66</sup>                   | Chinchillas/use with caution; objectionable taste may result in reduced food consumption                |
|                               | 10-40 mg/kg PO q24h <sup>66</sup>                   | Mice, rats                                                                                              |
|                               | 10-40 mg/rat PO q24h <sup>1</sup>                   | Rat                                                                                                     |
|                               | 20-60 mg/kg PO q8-12h <sup>1</sup>                  | Prairie dogs                                                                                            |
|                               |                                                     |                                                                                                         |

|                 |                                                            |                                                                                                                                        |
|-----------------|------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------|
|                 | 2.5 mg/mL<br>drinking water<br>× 5 day <sup>13</sup>       | Mice                                                                                                                                   |
| Neomycin        | 8 mg/kg PO<br>q24h <sup>12</sup>                           | Guinea pigs/best to avoid or use with caution                                                                                          |
|                 | 15 mg/kg PO<br>q24h <sup>12</sup>                          | Chinchillas/best to avoid or use with caution                                                                                          |
|                 | 25 mg/kg PO<br>q12h <sup>16,66</sup>                       | Mice, rats, hamsters                                                                                                                   |
|                 | 100 mg/kg PO,<br>SC q24h <sup>1,12</sup>                   | Gerbils, hamsters                                                                                                                      |
|                 | 0.5 mg/mL<br>drinking water <sup>3</sup>                   | Hamsters/proliferative ileitis                                                                                                         |
|                 | 2.6 mg/mL<br>drinking water <sup>3</sup>                   | Mice, rats, gerbils                                                                                                                    |
| Netilmicin      | 6-8 mg/kg SC,<br>IM, IV divided<br>q8-24h <sup>76</sup>    | Chinchillas, guinea pigs/ <i>Pseudomonas</i>                                                                                           |
| Nystatin        | 60,000-90,000<br>U/kg PO q12h ×<br>7-10 days <sup>23</sup> | Chinchillas/gastrointestinal mycoses (not absorbed from<br>gastrointestinal tract); can be used topically in case of<br>dermatomycoses |
| Oxytetracycline | 5 mg/kg IM<br>q12h <sup>1,3</sup>                          | Guinea pigs/toxicity in guinea pigs reported <sup>73</sup>                                                                             |
|                 | 10 mg/kg PO<br>q8h <sup>13,19</sup>                        | Gerbils                                                                                                                                |
|                 | 10-20 mg/kg<br>PO q8h <sup>13</sup>                        | Mice, rats/Tyzzer's disease (mice); <i>Mycoplasma pneumonia</i><br>(rats)                                                              |
|                 | 16 mg/kg SC<br>q24h <sup>13,19</sup>                       | Hamsters                                                                                                                               |
|                 | 50 mg/kg PO<br>q12h <sup>19</sup>                          | Chinchillas, guinea pigs/toxicity in guinea pigs reported <sup>49</sup>                                                                |
|                 | 60 mg/kg IM<br>q3d <sup>78</sup>                           | All species                                                                                                                            |
|                 | 100 mg/kg SC<br>q24h <sup>78</sup>                         | All species                                                                                                                            |
|                 | 0.25-1 mg/mL<br>drinking<br>water <sup>13,19</sup>         | Hamsters, mice, rats, gerbils                                                                                                          |
|                 | 3 g/L in<br>drinking                                       | Chinchillas, guinea pigs/toxicity in guinea pigs reported <sup>72</sup>                                                                |



|                                              |                                                             |                                                               |
|----------------------------------------------|-------------------------------------------------------------|---------------------------------------------------------------|
|                                              | <a href="#">water</a> <sup>78</sup>                         |                                                               |
| Penicillin G                                 | —                                                           | Do not use in guinea pigs, chinchillas                        |
|                                              | 22,000 U/kg<br>SC, IM q24h <sup>66</sup>                    | Rats                                                          |
| Penicillin G<br>(benzathine and<br>procaine) | —                                                           | Do not use in guinea pigs                                     |
|                                              | 22,000 U/kg IM<br>q24h <sup>66,81</sup>                     | Chinchillas (use with caution), hamsters, gerbils, mice, rats |
| Sulfadimethoxine                             | 10-15 mg/kg<br>PO q12h <sup>33</sup>                        | All species                                                   |
| Sulfamerazine                                | 0.8 mg/mL<br>drinking water <sup>3</sup>                    | Gerbils                                                       |
|                                              | 1 mg/mL<br>drinking water <sup>3</sup>                      | Chinchillas, hamsters, guinea pigs, mice, rats                |
|                                              | 1 mg/4 g feed <sup>13</sup>                                 | Mice, rats                                                    |
| Sulfamethazine                               | 0.8 mg/mL<br>drinking water <sup>3</sup>                    | Gerbils                                                       |
|                                              | 1 mg/mL<br>drinking water <sup>3</sup>                      | Chinchillas, hamsters, guinea pigs, mice, rats                |
| Sulfaquinoxaline                             | 0.25-1 mg/mL<br>drinking<br>water <sup>13</sup>             | Mice, rats, chinchillas, gerbils, guinea pigs, hamsters       |
|                                              | 0.05% feed <sup>13</sup>                                    | Rats                                                          |
| Terbinafine                                  | 10-30 mg/kg<br>PO q24h × 4-6<br>wk <sup>35</sup>            | Most species/antifungal                                       |
| Tetracycline                                 | 10 mg/kg PO<br>q8-12h <sup>66</sup>                         | Guinea pigs/use with caution: toxicity reported <sup>72</sup> |
|                                              | 10 mg/kg PO<br>q24h <sup>1</sup>                            | Guinea pigs/use with caution: toxicity reported <sup>72</sup> |
|                                              | 10-20 mg/kg<br>PO q8-12h <sup>1,13</sup>                    | Hamsters, gerbils, mice, rats, prairie dogs, chinchillas      |
|                                              | 20 mg/kg IM<br>q24h <sup>3</sup>                            | Gerbils                                                       |
|                                              | 0.32 mg/mL<br>drinking<br>water <sup>13</sup>               | Chinchillas                                                   |
|                                              | 0.4 mg/mL<br>drinking water<br>× 10 days <sup>3,13,14</sup> | Hamsters/outbreaks of proliferative ileitis <sup>14</sup>     |
|                                              | 0.7 mg/mL                                                   |                                                               |

|                         |                                                   |                                                                                                    |
|-------------------------|---------------------------------------------------|----------------------------------------------------------------------------------------------------|
|                         | drinking water <sup>13</sup>                      | Guinea pigs/toxicity reported <sup>72</sup>                                                        |
|                         | 2-5 mg/mL drinking water <sup>13</sup>            | Gerbils, mice, rats                                                                                |
|                         | 0.1-0.5% feed × 14 days <sup>13</sup>             | Rats                                                                                               |
| Trimethoprim/sulfa      | —                                                 | Tissue necrosis may occur when given SC <sup>33</sup>                                              |
|                         | 15-30 mg/kg PO, SC, IM q12h <sup>1,19,33,66</sup> | Chinchillas, guinea pigs, hamsters, mice, rats, prairie dogs                                       |
|                         | 48-96 mg/kg PO q24h <sup>1</sup>                  | Rats                                                                                               |
| Tylosin (Tylan, Elanco) | 2-8 mg/kg PO, SC, IM q12h <sup>13,19</sup>        | Hamsters/use with caution                                                                          |
|                         | 10 mg/kg PO, SC q12h <sup>a,19</sup>              | Chinchillas, guinea pigs, mice, rats/toxicity reported in guinea pigs <sup>76</sup>                |
|                         | 10 mg/kg PO, SC, IM q24h <sup>18</sup>            | Chinchillas, guinea pigs, gerbils, mice, rats/toxicity reported in guinea pigs <sup>76</sup>       |
|                         | 0.5 mg/mL (500 mg/L) drinking water <sup>17</sup> | Gerbils, hamsters, mice, rats/PD in rats; <sup>17</sup> toxicity in hamsters reported <sup>3</sup> |
| Vancomycin              | 20 mg/kg PO q24h <sup>45</sup>                    | Tyzzer's disease                                                                                   |

- Chinchillas: penicillins (including ampicillin, amoxicillin), cephalosporins, clindamycin, erythromycin, lincomycin.
- Guinea pigs: penicillins (including ampicillin, amoxicillin), cefazolin, clindamycin, erythromycin, lincomycin, dihydrostreptomycin, streptomycin, bacitracin, chlortetracycline, oxytetracycline, tetracycline, tylosin.
- Hamsters: penicillins (including ampicillin, amoxicillin), cephalosporins, clindamycin, erythromycin, lincomycin, vancomycin, dihydrostreptomycin, streptomycin, bacitracin, oral gentamicin, tylosin.

<sup>a</sup> Antibiotic treatment can result in enteritis and antibiotic associated clostridial enterotoxemia, especially when antibiotics with a primary gram-positive spectrum

are given. Incidence is higher when agents are given orally. Chinchillas, guinea pigs, and hamsters are most susceptible. Also, direct toxicity due to streptomycin and dihydrostreptomycin occurs in gerbils, guinea pigs, hamsters, and mice. Procaine, included in some penicillin preparations, can be toxic to mice and guinea pigs. Guinea pigs and chinchillas are highly susceptible to the ototoxic effects of chloramphenicol and aminoglycosides at dosages above those recommended clinically. Antibiotics implicated in antibiotic-associated clostridial enterotoxemia include [3,5,17,19,33,41,72,76](#)

TABLE 8-2 Antiparasitic Agents Used in Rodents.

| Agent                                                      | Dosage                                                           | Comments                                                                                                 |
|------------------------------------------------------------|------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------|
| Albendazole                                                | 5 mg/kg PO q12h <sup>8</sup>                                     | Guinea pigs                                                                                              |
|                                                            | 25 mg/kg PO q12h × 2 days <sup>23</sup>                          | Chinchillas/giardiasis                                                                                   |
| Amitraz<br>(Mitaban,<br>Upjohn)                            | 1.4 mL/L topical q7-14d × 3-6 treatments <sup>33,66</sup>        | Gerbils, hamsters/demodectosis; apply with cottonball, brush; use with caution; not recommended in young |
|                                                            | 0.3% solution topically q7d <sup>66</sup>                        | Guinea pigs                                                                                              |
| Carbaryl powder (5%)                                       | Topical q7d × 3 treatments <sup>3</sup>                          | Chinchillas, guinea pigs/ectoparasites                                                                   |
| Dichlorvos strip (5 cm long)                               | Suspend 15 cm above cage × 24 hr, then 2×/wk × 3 wk <sup>3</sup> | All species/ectoparasites                                                                                |
| Dimetridazole                                              | 20-50 mg/kg PO q24h × 7 days <sup>8</sup>                        | Guinea pigs                                                                                              |
|                                                            | 1 mg/mL drinking water <sup>3</sup>                              | Mice, rats/gastrointestinal protozoa; not available in the United States                                 |
| Febantel                                                   | 10 mg/kg PO q24h × 3 days <sup>25</sup>                          | Most species/nematodiasis                                                                                |
| Fenbendazole                                               | 20-50 mg/kg PO q24h × 5 days <sup>2,14</sup>                     | All species/giardiasis; a lower dose is generally preferred                                              |
|                                                            | 0.3% feed × 14 days <sup>82</sup>                                | Mice/clinical trial for cestodes, pinworms                                                               |
| Fipronil<br>(Frontline 9.8% [1 mL contains 98 mg], Merial) | 7.5 mg/kg topically q30-60d <sup>77</sup>                        | Hamsters, mice, chipmunks/flea adulticide                                                                |
|                                                            | 3 mL/kg topically <sup>25</sup>                                  | Guinea pig/safety not determined (use with caution)                                                      |

|                                                           |                                                                    |                                                                                                                                                                                                          |
|-----------------------------------------------------------|--------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Imidacloprid<br>(Advantage,<br>Bayer)                     | ½ kitten dose<br>topically <sup>66</sup>                           | Prairie dogs                                                                                                                                                                                             |
|                                                           | 20 mg/kg topically<br>q30d <sup>25</sup>                           | Most species/flea control                                                                                                                                                                                |
| Imidacloprid<br>10%/moxidectin<br>1% (Advocate,<br>Bayer) | 0.1 mL/animal <sup>45</sup>                                        | Guinea pigs-ectoparasites (i.e., fleas, biting lice, mites)                                                                                                                                              |
| Ivermectin                                                | 0.2-0.4 mg/kg SC<br>q7-14d <sup>65,66</sup>                        | Chinchillas, guinea pigs, hamsters, prairie dogs, mice,<br>rats/ectoparasites; preferred dosage appears to be 0.4 mg/kg<br>q7d (higher doses have also been reported); for <i>Demodex</i> ,<br>use q5-7d |
|                                                           | 0.5 mg/kg SC, repeat<br>q14d <sup>73</sup>                         | Guinea pigs/sarcoptid mites                                                                                                                                                                              |
|                                                           | Spray animals or<br>topical drops, 4-5<br>times/yr <sup>7,33</sup> | Mice/clinical trial for mite control; <sup>7</sup> use 1% ivermectin<br>diluted 1:100 with 1:1 propylene glycol:water (0.1 mg/mL);<br>sprayed onto mice or topical behind ear                            |
|                                                           | 8 mg/L drinking<br>water × 4 days/wk ×<br>5 wk <sup>51</sup>       | Mice/pinworms                                                                                                                                                                                            |
|                                                           | 25 mg/L drinking<br>water × 4 days/wk ×<br>5 wk <sup>51</sup>      | Rats/pinworms                                                                                                                                                                                            |
| Lime sulfur dip                                           | Dip q7d × 6 wk <sup>3</sup>                                        | All species/ectoparasites; dilute 1:40 with water                                                                                                                                                        |
| Malathion<br>powder (3-5%)                                | Topical 3×/wk × 3<br>wk <sup>3</sup>                               | Gerbils, hamsters, mice, rats/ectoparasites                                                                                                                                                              |
| Malathion<br>spray/dip                                    | Topical q7d × 3<br>treatments <sup>3</sup>                         | All species/ectoparasites; use 0.5% spray or 2% dip                                                                                                                                                      |
| Mebendazole                                               | 40 mg/kg PO q7d ×<br>21 days <sup>1</sup>                          | Mice, rats/pinworms                                                                                                                                                                                      |
|                                                           | 50-60 mg/kg PO<br>q12h × 5 days <sup>8</sup>                       | Chinchillas, degus, chipmunks                                                                                                                                                                            |
| Metronidazole                                             | 10-40 mg/animal<br>q24h PO <sup>1</sup>                            | Rats                                                                                                                                                                                                     |
|                                                           | 25 mg/kg PO q12h <sup>66</sup>                                     | Guinea pigs                                                                                                                                                                                              |
|                                                           | 40 mg/kg PO q24h <sup>66</sup>                                     | Prairie dogs                                                                                                                                                                                             |
|                                                           | 50 mg/kg PO q12h ×<br>5 days <sup>33,66</sup>                      | Chinchillas/giardiasis; use with caution                                                                                                                                                                 |
|                                                           | 70 mg/kg PO q8h <sup>1</sup>                                       | Hamsters                                                                                                                                                                                                 |
|                                                           | 2.5 mg/mL drinking                                                 |                                                                                                                                                                                                          |

|                                      |                                                                              |                                                                                 |
|--------------------------------------|------------------------------------------------------------------------------|---------------------------------------------------------------------------------|
|                                      | water × 5 days <sup>1</sup>                                                  | Mice, rats                                                                      |
| Moxidectin                           | —                                                                            | See imidacloprid                                                                |
| Nitenpyram<br>(Capstar,<br>Novartis) | 1 mg/kg PO once <sup>26</sup>                                                | Gerbils, hamsters, mice, rats/flystrike                                         |
| Permethrin                           | 0.25% dust in cage <sup>6</sup>                                              | All species/ectoparasites                                                       |
|                                      | Cotton ball soaked in<br>5% solution <sup>6</sup>                            | Most species/place in cage 4-5 wk                                               |
| Piperazine<br>adipate                | 200 mg/kg PO q24h<br>× 7 days, off 7 days,<br>on 7 days <sup>3</sup>         | Rats/pinworms                                                                   |
|                                      | 200-600 mg/kg PO<br>q24h × 7 days, off 7<br>days, on 7 days <sup>3</sup>     | Gerbils                                                                         |
|                                      | 500 mg/kg PO<br>q24h <sup>66</sup>                                           | Chinchillas                                                                     |
|                                      | 0.5 mg/mL drinking<br>water × 21 days <sup>3</sup>                           | Rats/pinworms                                                                   |
|                                      | 3-5 mg/mL drinking<br>water × 7 days, off 7<br>days, on 7 days <sup>66</sup> | Hamsters                                                                        |
|                                      | 4-7 mg/mL drinking<br>water × 3-10 days <sup>66</sup>                        | Guinea pigs, mice, rats                                                         |
| Piperazine citrate                   | 100 mg/kg PO q24h<br>× 2 days <sup>66</sup>                                  | Chinchillas                                                                     |
|                                      | 2-5 mg/mL drinking<br>water × 7 days, off 7<br>days, on 7 days <sup>3</sup>  | All species/pinworms                                                            |
|                                      | 10 mg/mL drinking<br>water × 7 days, off 7<br>days, on 7 days <sup>66</sup>  | Guinea pigs, hamsters                                                           |
| Praziquantel<br>(Droncit, Bayer)     | 6-10 mg/kg PO, <sup>33</sup><br>SC, <sup>66</sup> repeat in 10<br>days       | All species/cestodes                                                            |
|                                      | 30 mg/kg PO q14d ×<br>3 treatments <sup>14</sup>                             | Gerbils, mice, rats                                                             |
|                                      | 140 ppm in feed for<br>7 days <sup>1</sup>                                   | Mice                                                                            |
| Propoxur                             | Topical q7d <sup>25</sup>                                                    | Most species/flea control (cat and dog fleas are often<br>resistant); carbamate |

|                                 |                                                                                                      |                                                                                                                                                                                                                 |
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| Pyrantel pamoate                | 50 mg/kg PO <sup><a href="#">1</a></sup>                                                             | Most species/nematodiasis                                                                                                                                                                                       |
| Pyrethrin powder                | Topical 3×/wk × 3 wk <sup><a href="#">3</a></sup>                                                    | Gerbils, hamsters, mice, rats/ectoparasites                                                                                                                                                                     |
|                                 | Topical q7d × 3 treatments <sup><a href="#">3</a></sup>                                              | Chinchillas, guinea pigs/ectoparasites                                                                                                                                                                          |
| Pyrethrin shampoo (0.05%)       | Shampoo q7d × 4 treatments <sup><a href="#">81</a></sup>                                             | Hamsters, mice, rats/fleas                                                                                                                                                                                      |
| Quinacrine HCl                  | 75 mg/kg q8h <sup><a href="#">1</a></sup>                                                            | All species/giardiasis in chinchillas                                                                                                                                                                           |
| Selamectin (Revolution, Pfizer) | 6 mg/kg topically q30d <sup><a href="#">8</a></sup>                                                  | Chinchillas, degus, chipmunks                                                                                                                                                                                   |
|                                 | 20-30 mg/kg topically <sup><a href="#">80</a></sup>                                                  | Guinea pigs                                                                                                                                                                                                     |
|                                 | 15-30 mg/kg topically q21-28d × 2 treatments (q14d if <i>Demodex</i> ) <sup><a href="#">26</a></sup> | Most species/use 30 mg/kg with <i>Sarcoptes</i>                                                                                                                                                                 |
| Sulfadimethoxine                | 10-15 mg/kg PO q12h <sup><a href="#">33</a></sup>                                                    | All species/coccidiosis                                                                                                                                                                                         |
|                                 | 25-50 mg/kg PO q24h × 10 days <sup><a href="#">66</a></sup>                                          | Chinchillas, guinea pigs, hamsters/coccidiosis                                                                                                                                                                  |
|                                 | 50 mg/kg PO once, then 25 mg/kg q24h × 10-20 days <sup><a href="#">1</a></sup>                       | All species/coccidiosis                                                                                                                                                                                         |
| Sulfamerazine                   | 0.8 mg/mL drinking water <sup><a href="#">3</a></sup>                                                | Gerbils/coccidiosis                                                                                                                                                                                             |
|                                 | 1 mg/mL drinking water <sup><a href="#">3</a></sup>                                                  | Chinchillas, guinea pigs, hamsters, mice, rats/coccidiosis                                                                                                                                                      |
| Sulfamethazine                  | 0.8 mg/mL drinking water <sup><a href="#">3</a></sup>                                                | Gerbils/coccidiosis                                                                                                                                                                                             |
|                                 | 1 mg/mL drinking water <sup><a href="#">3</a></sup>                                                  | Chinchillas, guinea pigs, hamsters, mice, rats/coccidiosis                                                                                                                                                      |
|                                 | 1-5 mg/mL drinking water <sup><a href="#">1</a></sup>                                                | All species/coccidiosis                                                                                                                                                                                         |
| Sulfaquinoxaline                | 1 mg/mL drinking water × 14-21 days <sup><a href="#">1</a></sup>                                     | All species/coccidiosis                                                                                                                                                                                         |
| Thiabendazole                   | 50-100 mg/kg PO q24h × 5 days <sup><a href="#">2</a></sup>                                           | Chinchillas, gerbils, guinea pigs, hamsters, mice, rats/ascaridiasis                                                                                                                                            |
| Toltrazil (Baycox, Bayer)       | 10 mg/kg PO q24h × 3 days, off 3 days, on                                                            | Most species/drug of choice for coccidiosis; 2.5% solution has very low pH; needs to be diluted with equal parts water and propylene glycol (1:1:1); <sup><a href="#">80</a></sup> 5% solution does not need to |

|  |                                      |              |
|--|--------------------------------------|--------------|
|  | 3 days <sup>25</sup>                 | be diluted   |
|  | 25 ppm/L drinking water <sup>8</sup> | Most species |

TABLE 8-3 Chemical Restraint/Anesthetic Agents Used in Rodents.

| Agent                                            | Dosage                               | Comments                                                                                                                                                                                |
|--------------------------------------------------|--------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Acepromazine                                     | —                                    | See ketamine for combinations                                                                                                                                                           |
|                                                  | 0.5-1 mg/kg IM <sup>33</sup>         | Chinchillas, guinea pigs, hamsters, mice, rats/preanesthetic; causes seizures in gerbils                                                                                                |
| Atipamezole (Antisedan, Pfizer) <sup>a</sup>     | —                                    | Medetomidine reversal                                                                                                                                                                   |
|                                                  | 1 mg/kg SC <sup>75</sup>             | Guinea pigs, mice, rats                                                                                                                                                                 |
|                                                  | 1-2.5 mg/kg IP <sup>4,21</sup>       | Mice, rats                                                                                                                                                                              |
| Atropine                                         | 0.05-0.1 mg/kg SC <sup>33</sup>      | All species/some rats possess serum atropinesterase                                                                                                                                     |
|                                                  | 0.1-0.2 mg/kg SC, IM <sup>6</sup>    | Chinchillas, guinea pigs                                                                                                                                                                |
|                                                  | 0.1-0.4 mg/kg SC, IM <sup>6,66</sup> | Gerbils, hamsters, mice, rats                                                                                                                                                           |
| Dexmedetomidine <sup>b</sup> (Dexdomitor, Orion) | —                                    | α <sub>2</sub> agonist similar to medetomidine; <sup>b</sup> see ketamine for combination                                                                                               |
| Diazepam                                         | —                                    | See fentanyl/fluanisone and ketamine for combinations                                                                                                                                   |
|                                                  | 0.5-3 mg/kg IM <sup>3</sup>          | Guinea pigs/sedation                                                                                                                                                                    |
|                                                  | 1-5 mg/kg IM <sup>3,67</sup>         | All species/sedation; guinea pigs/calming effect for intense pruritus or sows apprehensive of young                                                                                     |
| Enflurane                                        | To effect                            | All species                                                                                                                                                                             |
| Fentanyl/droperidol (Innovar-Vet, Mallinckrodt)  | —                                    | Sedation; anesthesia; dilute 1:10 to reduce chance of inflammation at injection site; <sup>3</sup> irritation can result in self-mutilation; caution: do not use in gerbils or hamsters |
|                                                  | 0.06-0.3 mL/kg IM <sup>6</sup>       | Mice/sedation                                                                                                                                                                           |
|                                                  | 0.1-0.5 mL/kg IM <sup>3,6</sup>      | Rats/sedation                                                                                                                                                                           |
|                                                  | 0.22-0.88 mL/kg IM <sup>3</sup>      | Guinea pigs/sedation; inflammation at injection site at high end of dose range                                                                                                          |

|                                        |                                                         |                                                                                                                |
|----------------------------------------|---------------------------------------------------------|----------------------------------------------------------------------------------------------------------------|
| Fentanyl/fluanisone (Hypnorm, Janssen) | —                                                       | Anesthesia                                                                                                     |
|                                        | 0.2-0.6 mL/kg IM, IP <sup>74</sup>                      | Mice, rats                                                                                                     |
|                                        | 0.5-1 mL/kg IM <sup>74</sup>                            | Guinea pigs                                                                                                    |
| Fentanyl/fluanisone (F)/diazepam (D)   | —                                                       | Anesthesia; 45 to 60 min duration                                                                              |
|                                        | (F) 0.4 mL/kg IP + (D) 2.5 mg/kg IP <sup>75</sup>       | Rats                                                                                                           |
|                                        | (F) 0.4 mL/kg IP + (D) 5 mg/kg IP <sup>75</sup>         | Mice                                                                                                           |
|                                        | (F) 1 mL/kg IM + (D) 2.5 mg/kg IM <sup>75</sup>         | Guinea pigs                                                                                                    |
| Fentanyl/fluanisone/midazolam          | —                                                       | Anesthesia; 45 to 60 min duration; 1 part Hypnorm, 1 part midazolam, 2 part sterile water                      |
|                                        | 2.7 mL/kg <sup>75</sup> IM, IP                          | Rats                                                                                                           |
|                                        | 8 mL/kg <sup>75</sup> IM, IP                            | Guinea pigs                                                                                                    |
|                                        | 10 mL/kg <sup>75</sup> IM, IP                           | Mice                                                                                                           |
| Glycopyrrolate                         | 0.01-0.02 mg/kg SC <sup>43</sup>                        | All species/excess oral or respiratory mucus                                                                   |
| Isoflurane                             | 2-5% induction then 0.25-4% maintenance <sup>3,43</sup> | All species/inhalant anesthetic of choice                                                                      |
| Ketamine                               | —                                                       | Ketamine combinations follow                                                                                   |
|                                        | 20-40 mg/kg IM <sup>3,66</sup>                          | Chinchillas, hamsters/light sedation; heavy sedation at higher doses in hamsters (marked individual variation) |
|                                        | 22 mg/kg IM <sup>3</sup>                                | Mice, rats/light sedation; heavy sedation at 44 mg/kg in mice and 25-40 mg/kg in rats                          |
|                                        | 22-44 mg/kg IM <sup>66</sup>                            | Guinea pigs/light sedation; heavy sedation at higher doses (marked individual variation)                       |
|                                        | 40-60 mg/kg IM <sup>3</sup>                             | Gerbils/light sedation; heavy sedation at higher doses (marked individual variation)                           |
| Ketamine (K)/acepromazine (A)          | (K) 40 mg/kg + (A) 0.5 mg/kg                            | Chinchillas/anesthesia; acepromazine not for use in gerbils (prolonged recovery)                               |



|                                                |                                                                        |                                                                                                             |
|------------------------------------------------|------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------|
|                                                | IM <sup>41,44,64</sup> 50-150 mg/kg + (A) 2.5-5 mg/kg IM <sup>63</sup> | Mice, rats/lower end of doses preferred                                                                     |
| Ketamine (K)/dexmedetomidine (De) <sup>c</sup> | (K) 75 mg/kg + (De) 0.5 mg/kg IP <sup>4</sup>                          | Mice, rats                                                                                                  |
| Ketamine (K)/diazepam (D)                      | (K) 20-30 mg/kg + (D) 1-2 mg/kg IM <sup>72</sup>                       | Guinea pigs/anesthesia                                                                                      |
|                                                | (K) 20-40 mg/kg + (D) 1-2 mg/kg IM <sup>41</sup>                       | Chinchillas/anesthesia                                                                                      |
| Ketamine (K)/medetomidine (Me)                 | (K) 40 mg/kg + (Me) 0.5 mg/kg IM, <sup>75</sup> IP <sup>46</sup>       | Guinea pigs/20-30 min duration of anesthesia                                                                |
|                                                | (K) 50-75 mg/kg + (Me) 1 mg/kg IP <sup>21</sup>                        | Mice/anesthesia; minor procedures; use the higher dose of ketamine in females; (Me) reversal is atipamezole |
|                                                | (K) 75-90 mg/kg + (Me) 0.5 mg/kg IM, IP <sup>66,75</sup>               | Rats, gerbils/surgical anesthesia 20-30 min duration                                                        |
|                                                | (K) 75-90 mg/kg + (Me) 1 mg/kg IM, IP <sup>66</sup>                    | Mice                                                                                                        |
| Ketamine (K)/midazolam (Mi)                    | (K) 5-10 mg/kg + (Mi) 0.5-1 mg/kg IM <sup>66</sup>                     | Chinchillas, guinea pigs, prairie dogs                                                                      |
| Ketamine (K)/xylazine (X)                      | (K) 20-40 mg/kg + (X) 2 mg/kg IM <sup>33</sup>                         | Guinea pigs/light anesthesia                                                                                |
|                                                | (K) 35-40 mg/kg + (X) 4-8 mg/kg IM <sup>3</sup>                        | Chinchillas/anesthesia                                                                                      |
|                                                | (K) 50 mg/kg + (X) 2 mg/kg IP <sup>3</sup>                             | Gerbils/anesthesia                                                                                          |
|                                                | (K) 50 mg/kg + (X) 5 mg/kg IP <sup>33</sup>                            | Mice/anesthesia                                                                                             |
|                                                | (K) 75-95                                                              |                                                                                                             |

|                                                                |                                                                       |                                                                                                                         |
|----------------------------------------------------------------|-----------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------|
|                                                                | mg/kg + (X) 5<br>mg/kg IM, IP <sup><a href="#">33</a></sup>           | Rats/anesthesia                                                                                                         |
|                                                                | (K) 80 mg/kg +<br>(X) 5 mg/kg<br>IM, IP <sup><a href="#">33</a></sup> | Hamsters/anesthesia                                                                                                     |
| Medetomidine <sup><a href="#">b</a></sup> (Domitor,<br>Pfizer) | —                                                                     | See ketamine for combinations; not commercially<br>available <sup>b</sup>                                               |
|                                                                | 0.03-0.1 mg/kg<br>SC <sup><a href="#">50</a></sup>                    | Mice, rats/light to moderate sedation                                                                                   |
|                                                                | 0.1 mg/kg SC <sup><a href="#">50</a></sup>                            | Hamsters/light to moderate sedation                                                                                     |
|                                                                | 0.1-0.2 mg/kg<br>SC <sup><a href="#">50</a></sup>                     | Gerbils/light to moderate sedation                                                                                      |
|                                                                | 0.3 mg/kg SC <sup><a href="#">50</a></sup>                            | Guinea pigs/variable effects                                                                                            |
| Midazolam                                                      | —                                                                     | See ketamine for combination                                                                                            |
|                                                                | 1-2 mg/kg IM <sup><a href="#">33</a></sup>                            | All species/preanesthetic                                                                                               |
| Nalorphine                                                     | 2-5 mg/kg IV <sup><a href="#">3</a></sup>                             | All species/narcotic reversal                                                                                           |
| Naloxone                                                       | 0.01-0.1 mg/kg<br>SC, IP <sup><a href="#">43</a></sup>                | All species/narcotic reversal                                                                                           |
| Pentobarbital                                                  | —                                                                     | Anesthesia; not recommended; marginal analgesia;<br>autonomic depression; give diluted in sterile saline<br>(<10 mg/mL) |
|                                                                | 30-45 mg/kg<br>IP <sup><a href="#">33</a></sup>                       | Guinea pigs, rats                                                                                                       |
|                                                                | 35-40 mg/kg<br>IP <sup><a href="#">3</a></sup>                        | Chinchillas                                                                                                             |
|                                                                | 50-90 mg/kg<br>IP <sup><a href="#">33</a></sup>                       | Gerbils, hamsters, mice                                                                                                 |
| Pipothiazine palmitate                                         | —                                                                     | Long-acting neuroleptic drug; antipsychotic<br>(experimental)                                                           |
|                                                                | 25 mg/kg SC<br>q5wk <sup><a href="#">61</a></sup>                     | Rats                                                                                                                    |
| Propofol                                                       | —                                                                     | Anesthesia; induction                                                                                                   |
|                                                                | 3-5 mg/kg IV <sup><a href="#">66</a></sup>                            | Guinea pigs, chinchillas, prairie dogs                                                                                  |
|                                                                | 7.5-10 mg/kg<br>IV <sup><a href="#">28</a></sup>                      | Rats                                                                                                                    |
|                                                                | 12-26 mg/kg<br>IV <sup><a href="#">28</a></sup>                       | Mice                                                                                                                    |
| Sevoflurane                                                    | To effect <sup><a href="#">66</a></sup>                               | Most species                                                                                                            |
| Tiletamine/zolazepam                                           | —                                                                     | Tiletamine/zolazepam combinations follow                                                                                |

|                                          |                                                        |                                                      |
|------------------------------------------|--------------------------------------------------------|------------------------------------------------------|
| (Telazol, Fort Dodge)                    | 20-40 mg/kg<br>IM <sup>24,41,44</sup>                  | Chinchillas, rats/anesthesia                         |
|                                          | 50-80 mg/kg<br>IM <sup>63</sup>                        | Mice, rats                                           |
| Tiletamine/zolazepam<br>(T)/xylazine (X) | (T) 20 mg/kg +<br>(X) 10 mg/kg<br>IP <sup>43</sup>     | Gerbils/anesthesia                                   |
|                                          | (T) 30 mg/kg +<br>(X) 10 mg/kg<br>IM, IP <sup>33</sup> | Hamsters/anesthesia                                  |
| Xylazine                                 | —                                                      | See ketamine, tiletamine/zolazepam for combinations  |
|                                          | 5-10 mg/kg SC,<br>IM, IP <sup>63</sup>                 | Most species/may cause muscle necrosis when given IM |
| Yohimbine (Yobine, Lloyd)                | 0.5-1 mg/kg<br>IV <sup>33</sup>                        | All species/xylazine reversal                        |

Use stock solution (rat):

Ketamine (100 mg/mL) = 3 mL

Dexmedetomidine (0.5 mg/mL) = 0.1 mL

Sterile water = 4.9 mL

<sup>a</sup> Atipamezole: to make 0.25 mg/mL stock solution, make a 1:20 dilution; add 1 mL atipamezole to 19 mL sterile water; give 0.1 mL SC or IP of 0.25 mg/mL stock solution to 10 g of mouse. Rat dosage: make 0.25 mg/mL stock solution, as described above; give 0.6 mL per 150 g rat weight SC or IP.

<sup>b</sup> Medetomidine is no longer commercially available although it can be obtained from select compounding services (i.e., Diamondback Drugs, [www.diamondbackdrugs.com](http://www.diamondbackdrugs.com); Wildlife Pharmaceuticals, [www.wildpharm.com](http://www.wildpharm.com)). Dexmedetomidine is an  $\alpha_2$  agonist that is the active optical enantiomer of racemic compound medetomidine. Usually  $\frac{1}{2}$  the dose of medetomidine is needed but it remains the same volume due to concentration differences; the same effects can be expected as with medetomidine but there is limited data on the efficacy and safety of dexmedetomidine in rodents; the effects of the v / v use of the two drugs may

not be equivalent, so the dose of dexmedetomidine may need to be adjusted based on clinical response.

<sup>c</sup> Use stock solution (mice):

From above made solution, give 0.1 mL/10 g of mouse IP (= 0.2 mL/20 g mouse; 0.3 mL/30 g mouse).From above made solution, give 0.2 mL/100 g of rat IP.

TABLE 8-4 Analgesic Agents Used in Rodents.

| Agent                                 | Dosage                                              | Comments                                              |
|---------------------------------------|-----------------------------------------------------|-------------------------------------------------------|
| Acetaminophen (Tylenol syrup, McNeil) | 200 mg/kg PO <sup>1</sup>                           | Mice, rats                                            |
|                                       | 1-2 mg/mL drinking water <sup>43</sup>              | All                                                   |
| Acetylsalicylic acid (aspirin)        | —                                                   | Analgesia; antipyretic; nonsteroidal antiinflammatory |
|                                       | 50-100 mg/kg PO q4h <sup>37</sup>                   | Guinea pigs                                           |
|                                       | 100 mg/kg PO q48h <sup>50</sup>                     | Rats                                                  |
|                                       | 100-150 mg/kg PO q4h <sup>37</sup>                  | Gerbils, hamsters, mice, rats                         |
|                                       | 100-200 mg/kg PO q6-8h <sup>50</sup>                | Chinchillas                                           |
|                                       | 120 mg/kg PO q4h <sup>50,54</sup>                   | Mice                                                  |
|                                       | 240 mg/kg PO q24h <sup>81</sup>                     | Gerbils, hamsters                                     |
| Buprenorphine                         | 0.02-0.5 mg/kg SC, IV, IP q6-12h <sup>33</sup>      | Rats                                                  |
|                                       | 0.05 mg/kg SC, IM <sup>55</sup>                     | Rats/combine with carprofen (5-10 mg/kg PO)           |
|                                       | 0.05-0.1 mg/kg SC q6-12h <sup>81</sup>              | All species                                           |
|                                       | 0.1-0.2 mg/kg SC q8h <sup>33</sup>                  | Gerbils                                               |
|                                       | 0.5 mg/kg SC q8h <sup>33</sup>                      | Hamsters                                              |
| Butorphanol                           | 0.2-2 mg/kg SC, IM, IP q2-4h <sup>33,46,66,70</sup> | Mice, rats, chinchillas, guinea pigs                  |
|                                       | 1-5 mg/kg SC                                        |                                                       |

|                             |                                                              |                                                                                        |
|-----------------------------|--------------------------------------------------------------|----------------------------------------------------------------------------------------|
|                             | q4h <sup><a href="#">37,66</a></sup>                         | Gerbils, hamsters, mice                                                                |
| Carprofen (Rimadyl, Pfizer) | —                                                            | Nonsteroidal antiinflammatory                                                          |
|                             | 1 mg/kg PO q12-24h <sup><a href="#">66</a></sup>             | Prairie dogs                                                                           |
|                             | 1-4 mg/kg/PO q12-24h <sup><a href="#">24,52</a></sup>        | Guinea pigs                                                                            |
|                             | 1.5 mg/kg PO q12h <sup><a href="#">70</a></sup>              | Rats                                                                                   |
|                             | 2-5 mg/kg PO, SC q12-24h <sup><a href="#">66</a></sup>       | Chinchillas, guinea pigs, mice, rats                                                   |
|                             | 5 mg/kg SC q24h <sup><a href="#">70</a></sup>                | Gerbils, hamsters, mice, rats                                                          |
|                             | 5-10 mg/kg PO <sup><a href="#">55</a></sup>                  | Rats/can combine with buprenorphine (0.05 mg/kg SC, IM)                                |
| Codeine                     | —                                                            | Narcotic                                                                               |
|                             | 10-20 mg/kg SC q6h <sup><a href="#">81</a></sup>             | Mice                                                                                   |
|                             | 60 mg/kg SC q4h <sup><a href="#">81</a></sup>                | Rats                                                                                   |
| Etomidate                   | 1-2 mg/kg IV <sup><a href="#">53</a></sup>                   | Most species/use with benzodiazepine to prevent seizures; short-acting induction agent |
| Flunixin meglumine          | —                                                            | Nonsteroidal antiinflammatory; give only if animal is well hydrated                    |
|                             | 0.3-2 mg/kg PO, IM, IV q12-24h <sup><a href="#">70</a></sup> | Mice                                                                                   |
|                             | 1-3 mg/kg SC, IM q12h <sup><a href="#">40,41</a></sup>       | Chinchillas                                                                            |
|                             | 1.1-2.5 mg/kg SC, IM q12h <sup><a href="#">70</a></sup>      | Rats                                                                                   |
|                             | 2.5 mg/kg SC q12-24h <sup><a href="#">37</a></sup>           | Gerbils, hamsters, mice, rats                                                          |
|                             | 2.5-5 mg/kg SC q12-24h <sup><a href="#">37</a></sup>         | Guinea pigs                                                                            |
| Gabapentin                  | 50 mg/kg PO q24h <sup><a href="#">31</a></sup>               | Hamsters                                                                               |
| Ibuprofen                   | —                                                            | Antiinflammatory                                                                       |
|                             | 7-15 mg/kg PO q4h <sup><a href="#">33</a></sup>              | Mice                                                                                   |
|                             | 10 mg/kg PO q4h <sup><a href="#">33</a></sup>                | Guinea pigs                                                                            |
|                             | 10-30 mg/kg PO q4h <sup><a href="#">27,33,48</a></sup>       | Rats                                                                                   |
|                             | 1 mg/kg SC, IM                                               |                                                                                        |

|                                                     |                                                                |                                                |
|-----------------------------------------------------|----------------------------------------------------------------|------------------------------------------------|
| Ketoprofen                                          | q12-24h <sup><a href="#">66</a></sup>                          | Chinchillas, guinea pigs                       |
|                                                     | 1-3 mg/kg SC, IM<br>q12-24h <sup><a href="#">66</a></sup>      | Prairie dogs/doses of 3-5 mg/kg have been used |
|                                                     | 5 mg/kg PO, SC, IM<br>q24h <sup><a href="#">27,66,67</a></sup> | Most species                                   |
| Meloxicam (Metacam, Boehringer Ingelheim Vetmedica) | —                                                              | Nonsteroidal antiinflammatory                  |
|                                                     | ≥0.5 mg/kg PO, SC<br>q24h <sup><a href="#">66</a></sup>        | Chinchillas, guinea pigs, hamsters, gerbils    |
|                                                     | 1-2 mg/kg PO, SC<br>q24h <sup><a href="#">24,66,68</a></sup>   | Rats                                           |
|                                                     | 1-5 mg/kg PO, SC<br>q24h <sup><a href="#">66</a></sup>         | Mice                                           |
| Meperidine                                          | 10-20 mg/kg SC, IM<br>q2-3h <sup><a href="#">27</a></sup>      | Guinea pigs, mice, rats                        |
|                                                     | 20 mg/kg SC, IM<br>q2-3h <sup><a href="#">37</a></sup>         | Gerbils, guinea pigs, hamsters, mice, rats     |
| Morphine                                            | —                                                              | Narcotic                                       |
|                                                     | 2-5 mg/kg SC, IM<br>q4h <sup><a href="#">37,66,81</a></sup>    | Chinchillas, guinea pigs, mice, rats           |
|                                                     | 2-5 mg/kg SC, IM<br>q2-4h <sup><a href="#">66</a></sup>        | Gerbils, hamsters                              |
| Nalbuphine (Nubain, Endo Labs)                      | 1-2 mg/kg IM q3h <sup><a href="#">37</a></sup>                 | Guinea pigs                                    |
|                                                     | 4-8 mg/kg IM q3h <sup><a href="#">37</a></sup>                 | Gerbils, hamsters, mice, rats                  |
| Oxymorphone                                         | —                                                              | Narcotic                                       |
|                                                     | 0.2-0.5 mg/kg SC, IM<br>q6-12h <sup><a href="#">37</a></sup>   | Gerbils, guinea pigs, hamsters, mice, rats     |
| Pentazocine (Talwin, Sanofi Winthrop)               | 10 mg/kg SC q24h <sup><a href="#">37</a></sup>                 | Gerbils, guinea pigs, hamsters, mice, rats     |
| Pethidine                                           | 10-20 mg/kg SC, IM<br>q2-3h <sup><a href="#">42</a></sup>      | Guinea pigs                                    |
| Piroxicam                                           | —                                                              | Nonsteroidal antiinflammatory                  |
|                                                     | 3.4-20 mg/kg PO <sup><a href="#">85</a></sup>                  | Mice                                           |
| Tramadol                                            | 5 mg/kg IM <sup><a href="#">32</a></sup>                       | Rats                                           |
|                                                     | 5-10 mg/kg PO q12-24h <sup><a href="#">57</a></sup>            | All species                                    |
|                                                     | 5-20 mg/kg PO, SC<br>q12-24h <sup><a href="#">66</a></sup>     | Rats                                           |
|                                                     | 5-40 mg/kg SC,                                                 | Mice                                           |

TABLE 8-5 Cardiovascular Agents Used in Rodents.

| Agent                             | Dosage                                                 | Comments                                                                                     |
|-----------------------------------|--------------------------------------------------------|----------------------------------------------------------------------------------------------|
| Atenolol                          | 0.2-2 mg/kg PO q24h <sup>45</sup>                      | Most species/beta-blocker; hypertension and tachyarrhythmias                                 |
| Atropine                          | 0.05-0.5 mg/kg <sup>1,45</sup> SC, IM                  | All species/preanesthetic, cardiac problems                                                  |
|                                   | 10 mg/kg SC q20min <sup>33</sup>                       | All species/organophosphate toxicity; may cause cardiovascular irregularities in guinea pigs |
| Benazepril                        | <0.1 mg/kg PO q24h <sup>45</sup>                       | Most species/ACE inhibitor; heart failure, hypertension, and chronic renal failure           |
| Digoxin                           | 0.05-0.1 mg/kg PO q12-24h <sup>65</sup>                | Hamsters/dilated cardiomyopathy                                                              |
| Diltiazem                         | 0.5-1 mg/kg PO q12-24h <sup>45</sup>                   | Most species/Ca channel blocker; hypertension and hypertrophic cardiomyopathy                |
| Dopamine                          | 0.08 mg/kg IV prn <sup>52</sup>                        | Guinea pigs/hypotension, especially anesthetic related                                       |
| Enalapril                         | 0.5-1 mg/kg PO q24h <sup>26</sup>                      | Most species/ACE inhibitor; heart failure                                                    |
| Epinephrine                       | 0.003 mg/kg IV prn <sup>52</sup>                       | Guinea pigs/cardiac arrest                                                                   |
|                                   | 0.1 mg/kg IV <sup>66</sup>                             | Most species                                                                                 |
| Furosemide                        | 0.3-4 mg/kg PO, SC, IM, IV q12-24h <sup>45</sup>       | Most species/congestive heart failure                                                        |
| Glyceryl trinitrate ointment (2%) | 3 mm strip applied to inner pinna q6-12h <sup>45</sup> | Most species/congestive heart failure                                                        |
| Glycopyrrolate                    | 0.01-0.1 mg/kg SC, IM, IV <sup>43</sup>                | Most species/anticholinergic agent used for bradycardia; premedication                       |
| Lidocaine                         | 1-2 mg/kg IV or 2-4 mg/kg IT <sup>45</sup>             | Most species/arrhythmias                                                                     |
| Pimobendan                        | 0.2-0.4 mg/kg PO q12h <sup>62</sup>                    | Most species/inodilator for treating heart failure                                           |
| Taurine                           | 100 mg/kg PO q12h × 8 wk <sup>45</sup>                 | Most species/cardiomyopathy                                                                  |

TABLE 8-6 Emergency Drugs Used in Rodents.

| Agent    | Dosage                            | Comments                                                    |
|----------|-----------------------------------|-------------------------------------------------------------|
| Atropine | 0.05-0.1 mg/kg SC <sup>33</sup>   | All species/bradycardia; some rats possess serum atropinase |
|          | 0.1-0.2 mg/kg SC, IM <sup>3</sup> | Chinchillas, guinea pigs                                    |
|          |                                   |                                                             |

|                            |                                               |                                                                         |
|----------------------------|-----------------------------------------------|-------------------------------------------------------------------------|
|                            | 0.4 mg/kg SC, IM <sup>3</sup>                 | Gerbils, hamsters, mice, rats                                           |
|                            | 10 mg/kg SC q20min <sup>33</sup>              | All species/organophosphate toxicity                                    |
| Calcium gluconate          | 100 mg/kg IM <sup>39</sup>                    | Guinea pigs/dystocia; follow with 1 U oxytocin (see Table 8-7)          |
|                            | 100 mg/kg IP <sup>77</sup>                    | Chinchillas/hypocalcemic tetany; eclampsia                              |
| Dexamethasone              | —                                             | All species/antiinflammatory                                            |
|                            | 0.5-2 mg/kg SC, IM, IV <sup>66</sup>          | Use with caution in guinea pigs and chinchillas                         |
|                            | 0.6 mg/kg IM <sup>1</sup>                     | Guinea pigs/pregnancy toxemia                                           |
|                            | 4-5 mg/kg SC, IM, IP, IV <sup>65</sup>        | Shock                                                                   |
| Diazepam                   | 1-2 mg/kg IM <sup>76</sup>                    | Guinea pigs/calming effect for intense pruritus                         |
|                            | 1-5 mg/kg IM, IV, IP, IO <sup>65</sup>        | All/treatment of seizures                                               |
| Diphenhydramine            | —                                             | Antihistamine; anaphylaxis                                              |
|                            | 1-2 mg/kg PO, SC q12h <sup>66</sup>           | All species                                                             |
|                            | 1-5 mg/kg SC <sup>52,66</sup> prn             | Guinea pigs                                                             |
| Dopamine                   | 0.08 mg/kg IV <sup>52</sup>                   | Guinea pigs/hypotension                                                 |
| Doxapram                   | —                                             | Respiratory stimulant                                                   |
|                            | 2-5 mg/kg IV, IP <sup>33</sup>                | Guinea pigs                                                             |
|                            | 5-10 mg/kg IV, IP <sup>33</sup>               | Chinchillas, gerbils, hamsters, mice, rats                              |
| Ephedrine                  | 1 mg/kg IV <sup>52</sup>                      | Guinea pigs/antihistamine; stimulant                                    |
| Epinephrine                | 0.003 mg/kg IV <sup>52</sup>                  | Guinea pigs/cardiac arrest                                              |
| Furosemide                 | —                                             | Diuretic for edema, pulmonary congestion, ascites                       |
|                            | 1-4 mg/kg SC, IM q4-6h <sup>35</sup>          | All species                                                             |
|                            | 5-10 mg/kg SC, IM q12h <sup>2,35</sup>        | All species                                                             |
| Glycopyrrolate             | 0.01-0.02 mg/kg SC <sup>43</sup>              | All species/bradycardia                                                 |
| Lactated Ringer's solution | 10-25 mL/kg IV <sup>69</sup>                  | Most species/give slowly over 5-10 min (if unsuccessful, administer IP) |
| Vitamin C (ascorbic acid)  | 50-100 mg/kg PO, SC, IM q24h <sup>66,76</sup> | Guinea pigs/ascorbic acid deficiency (scurvy)                           |

TABLE 8-7 Miscellaneous Agents Used in Rodents.

| Agent          | Dosage                            | Comments                                             |
|----------------|-----------------------------------|------------------------------------------------------|
| Acetylcysteine | 3 mg/kg PO, SC q12h <sup>26</sup> | Most species/injectable can be used for nebulization |



|                                   |                                                                                         |                                                                                                                   |
|-----------------------------------|-----------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------|
| Activated charcoal                | 1 g/kg PO <sup><a href="#">80</a></sup>                                                 | Most species/use only in cases of toxicity (not with general diarrhea)                                            |
| Aluminum hydroxide                | 20-40 mg/animal PO prn <sup><a href="#">76</a></sup>                                    | Guinea pigs/hyperphosphatemia caused by renal failure                                                             |
| Aminophylline                     | 50 mg/kg PO, SC <sup><a href="#">1,66</a></sup>                                         | Guinea pigs                                                                                                       |
| Atropine (1%)/phenylephrine (10%) | Topical to eyes <sup><a href="#">33</a></sup>                                           | All species/mydriasis for non-albino eyes                                                                         |
| Barium sulfate (1000 mg/mL)       | 5-10 mL/kg PO <sup><a href="#">80</a></sup>                                             | Most species/contrast studies; might need to be diluted with water (1:1)                                          |
| Cabergoline                       | 5 µg/kg PO q2h × 5 days <sup><a href="#">80</a></sup>                                   | Most species/pseudopregnancy                                                                                      |
|                                   | 0.6 mg/kg PO, SC q72h <sup><a href="#">59</a></sup>                                     | Rats/pituitary tumor                                                                                              |
| Calcium EDTA                      | 30 mg/kg SC q12h <sup><a href="#">41,66</a></sup>                                       | All species/lead chelation                                                                                        |
| Chlorpheniramine maleate          | 0.6 mg/kg PO q24h <sup><a href="#">1</a></sup>                                          | Guinea pigs/antihistamine                                                                                         |
| Cimetidine                        | 5-10 mg/kg PO, SC, IM, IV q6-12h <sup><a href="#">2</a></sup>                           | All species/gastric, duodenal ulceration; esophagitis, gastroesophageal reflux                                    |
| Cisapride (Propulsid, Janssen)    | 0.1-0.5 mg/kg PO q12h <sup><a href="#">66</a></sup>                                     | All species/enhance gastrointestinal motility; not commercially available in the United States; can be compounded |
|                                   | 0.5 mg/kg PO q8-12h <sup><a href="#">66</a></sup>                                       | Chinchillas, guinea pigs                                                                                          |
| Cyclophosphamide                  | 300 mg/kg IP q24h <sup><a href="#">52</a></sup>                                         | Guinea pigs/antineoplastic                                                                                        |
| Dexamethasone                     | —                                                                                       | Antiinflammatory                                                                                                  |
|                                   | 0.5-2 mg/kg PO, SC, then decreasing dose q12h × 3-14 days <sup><a href="#">33</a></sup> | All species                                                                                                       |
|                                   | 0.6 mg/kg                                                                               |                                                                                                                   |

|                                       |                                                                 |                                                             |
|---------------------------------------|-----------------------------------------------------------------|-------------------------------------------------------------|
|                                       | IM <sup>3</sup>                                                 | All species                                                 |
| Diphenhydramine                       | —                                                               | Antihistamine; anaphylaxis                                  |
|                                       | 1-2 mg/kg<br>PO, SC<br>q12h <sup>66</sup>                       | Chinchillas, hamsters, mice, rats                           |
|                                       | 5 mg/kg SC<br>prn <sup>52</sup>                                 | Guinea pigs                                                 |
| Diphenylhydantoin                     | 25-50<br>mg/kg<br>q12h <sup>45</sup>                            | Most species/seizures                                       |
| Ephedrine                             | 1 mg/kg PO,<br>IV prn <sup>52</sup>                             | Guinea pigs/antihistamine; anaphylaxis                      |
| Fluoxetine (Prozac, Eli Lilly/Dista)  | 5-10 mg/kg<br>PO q24h <sup>45</sup>                             | Most species/for behavioral problems (i.e., fur<br>chewing) |
| Furosemide                            | —                                                               | Diuretic for pulmonary congestion, edema,<br>ascites        |
|                                       | 1-4 mg/kg<br>IM q4-6h <sup>35</sup>                             | All species                                                 |
|                                       | 2-5 mg/kg<br>PO, SC, IM<br>q12h <sup>66</sup>                   | Chinchillas, guinea pigs                                    |
|                                       | 2-10 mg/kg<br>PO, SC, IM<br>q12h <sup>66</sup>                  | Gerbils, hamsters, mice, rats                               |
|                                       | 5-10 mg/kg<br>SC, IM<br>q12h <sup>2,35</sup>                    | All species                                                 |
| GnRH                                  | 20<br>µg/animal<br>IM once <sup>29</sup>                        | Ovarian cysts                                               |
|                                       | 25<br>µg/animal<br>q14d × 2<br>treatments <sup>56</sup>         | Guinea pigs/ovarian cysts                                   |
| Heparin                               | 5 mg/kg IV<br>prn <sup>52</sup>                                 | Guinea pigs/disseminated intravascular<br>coagulation       |
| Human chorionic gonadotropin<br>(hCG) | 1000<br>U/animal<br>IM, repeat<br>in 7-10<br>days <sup>72</sup> | Guinea pigs/cystic ovaries                                  |

|                                                                 |                                                                                               |                                                                                                                                                                                                                   |
|-----------------------------------------------------------------|-----------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Hydralazine                                                     | 1 mg/kg IV<br>prn <sup><a href="#">52</a></sup>                                               | Guinea pigs/hypertension                                                                                                                                                                                          |
| Insulin                                                         | 1 U/kg SC<br>q12h to<br>adjust, then<br>0.1 U/kg as<br>required <sup><a href="#">45</a></sup> | Chinchillas                                                                                                                                                                                                       |
|                                                                 | 1-2<br>U/animal<br>SC q12h <sup><a href="#">66</a></sup>                                      | Guinea pigs                                                                                                                                                                                                       |
|                                                                 | 1-3<br>U/animal<br>SC <sup><a href="#">66</a></sup>                                           | Rats                                                                                                                                                                                                              |
|                                                                 | 2 U/animal<br>SC <sup><a href="#">52,66</a></sup>                                             | Hamsters, gerbils                                                                                                                                                                                                 |
| Iodine, I-131 (radioactive)                                     | 1<br>mCi/animal<br>SC once <sup><a href="#">58</a></sup>                                      | Guinea pigs/hyperthyroidism                                                                                                                                                                                       |
| Kaolin pectin                                                   | 0.2 mL PO<br>q6-8h <sup><a href="#">1</a></sup>                                               | Guinea pigs/antidiarrheal                                                                                                                                                                                         |
| Lactated Ringer's solution                                      | 10-25<br>mL/kg IV<br>bolus over<br>5-10 min <sup><a href="#">1</a></sup>                      | Most species/warm to 37°C (99°F)                                                                                                                                                                                  |
|                                                                 | 50-100<br>mL/kg SC,<br>IV, IO<br>q24h <sup><a href="#">69</a></sup>                           | All species/maintenance fluid requirements                                                                                                                                                                        |
| Lactobacilli                                                    | —                                                                                             | All species/PO during antibiotic treatment<br>period, then 5-7 days beyond cessation; <sup><a href="#">19</a></sup> give 2<br>hr prior to or 2 hr following antibiotic<br>treatment <sup><a href="#">19</a></sup> |
| Lactulose                                                       | 0.5 mL/kg<br>PO q12h <sup><a href="#">45</a></sup>                                            | Most species/hepatic disorders; use with milk<br>thistle                                                                                                                                                          |
| Leuprolide acetate depot (Lupron<br>Depot, TAP Pharmaceuticals) | 0.2-0.3<br>mg/kg IM<br>q28d <sup><a href="#">67</a></sup>                                     | Guinea pigs/cystic ovaries                                                                                                                                                                                        |
| Levothyroxine                                                   | 5 µg/kg PO<br>q12h <sup><a href="#">45</a></sup>                                              | Most species/hypothyroidism                                                                                                                                                                                       |
| Loperamide                                                      | 0.1 mg/kg<br>PO q8h × 3<br>days, then                                                         | All species/enteropathies (diarrhea); give in 1                                                                                                                                                                   |

|                                                                 |                                                           |                                                                                                                                                                                                                                                                         |
|-----------------------------------------------------------------|-----------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                                                                 | q24h × 2 days <sup><a href="#">33</a></sup>               | mL water                                                                                                                                                                                                                                                                |
| Magnesium hydroxide                                             | 4 mg/kg PO <sup><a href="#">45</a></sup>                  | Helps prevent formation of calcium uroliths                                                                                                                                                                                                                             |
| Methimazole                                                     | 0.5-2 mg/kg PO q24h <sup><a href="#">58</a></sup>         | Guinea pigs/hyperthyroidism                                                                                                                                                                                                                                             |
| Metoclopramide                                                  | 0.2-1 mg/kg PO, SC, IM q12h <sup><a href="#">65</a></sup> | All species/gastric stasis                                                                                                                                                                                                                                              |
| Metyrapone                                                      | 8 mg/animal PO q24h × 4 wk <sup><a href="#">45</a></sup>  | Hamsters/hyperadrenocorticism                                                                                                                                                                                                                                           |
| Milk thistle ( <i>Silybum marianum</i> )                        | 4-15 mg/kg PO q8-12h <sup><a href="#">45</a></sup>        | Most species/hepatic disorders                                                                                                                                                                                                                                          |
| Mitotane                                                        | 5 mg/animal PO q24h × 4 wk <sup><a href="#">45</a></sup>  | Hamsters/hyperadrenocorticism                                                                                                                                                                                                                                           |
| Neomycin/dexamethasone/polymyxin B ophthalmic (Maxitrol, Alcon) | Topical to eyes q8-12h <sup><a href="#">65</a></sup>      | All species/ophthalmic preparation; may cause gastrointestinal stasis secondary to steroids                                                                                                                                                                             |
| Oxytocin                                                        | 0.2-3 U/kg SC, IM, IV <sup><a href="#">3</a></sup>        | All species/delayed parturition if unobstructed; caution in guinea pigs: fusion of pubic symphysis occurs if first breeding does not occur before 6-9 mo of age, resulting in dystocia; if no young produced 15 min following 1 U/animal, cesarean section is indicated |
|                                                                 | 1 U/kg SC, IM <sup><a href="#">1</a></sup>                | Rats                                                                                                                                                                                                                                                                    |
|                                                                 | 1-2 U/animal IM <sup><a href="#">1</a></sup>              | Guinea pigs/uterine contraction; milk letdown                                                                                                                                                                                                                           |
|                                                                 | 6.25 U/kg SC <sup><a href="#">1</a></sup>                 | Mice/milk letdown                                                                                                                                                                                                                                                       |
| Phenobarbital                                                   | 5-20 mg/kg PO, IV, IP <sup><a href="#">52,66</a></sup>    | Guinea pigs/antiseizure medication; sedative                                                                                                                                                                                                                            |
| Potassium citrate                                               | 10-30 mg/kg PO q12h <sup><a href="#">66</a></sup>         | Guinea pigs                                                                                                                                                                                                                                                             |

|                                                  |                                                                       |                                                                                                  |
|--------------------------------------------------|-----------------------------------------------------------------------|--------------------------------------------------------------------------------------------------|
| Prednisone                                       | 0.5-2.2<br>mg/kg PO,<br>SC, IM <sup><a href="#">3.66</a></sup>        | All species/antiinflammatory                                                                     |
| Pseudoephedrine                                  | 1.2<br>mg/animal<br>PO q12h <sup><a href="#">77</a></sup>             | Chinchillas/nasal and sinus decongestant                                                         |
| Simethicone                                      | 70 mg/kg<br>PO prn <sup><a href="#">80</a></sup>                      | Most species/gastrointestinal bloat                                                              |
| Sucralfate (Carafate, Hoechst Marion<br>Roussel) | 25-100<br>mg/kg PO<br>q8-12h <sup><a href="#">63.66</a></sup>         | All species/oral, esophageal, gastric, and<br>duodenal ulcers                                    |
| Theophylline                                     | 10 mg/kg<br>PO q8-<br>12h <sup><a href="#">66</a></sup>               | Prairie dogs                                                                                     |
| Thiamine                                         | 1 mg/kg<br>feed <sup><a href="#">45</a></sup>                         | Most species/thiamine deficiency                                                                 |
| Toremifene                                       | 12 mg/kg<br>PO q24h <sup><a href="#">45</a></sup>                     | Rats/pituitary hyperplasia/adenoma                                                               |
| Trilostane                                       | 2-4 mg/kg<br>PO q24h <sup><a href="#">45</a></sup>                    | Hyperadrenocorticism                                                                             |
| Tropicamide (1%)                                 | Topical to<br>eyes <sup><a href="#">33</a></sup>                      | All species/mydriasis in albino eyes                                                             |
| Vitamin A                                        | 50-500 U/kg<br>IM <sup><a href="#">52</a></sup>                       | Guinea pigs, hamsters                                                                            |
|                                                  | 2000<br>U/animal <sup><a href="#">45</a></sup>                        | Chinchillas/hypovitaminosis A                                                                    |
|                                                  | 2 µg<br>vitamin A<br>palmitate/g<br>feed <sup><a href="#">1</a></sup> | Hamsters                                                                                         |
|                                                  | 10 mg β-<br>carotene/kg<br>of feed <sup><a href="#">1</a></sup>       | Guinea pigs                                                                                      |
| Vitamin B complex (small animal)                 | 0.02-0.2<br>mL/kg SC,<br>IM <sup><a href="#">3.79</a></sup>           | All species/B <sub>1</sub> (100 mg/mL), B <sub>2</sub> (2 mg/mL), B <sub>12</sub><br>(0.1 mg/mL) |
| Vitamin C (ascorbic acid)                        | 10-30<br>mg/kg PO,<br>SC, IM <sup><a href="#">1</a></sup>             | Guinea pigs/maintenance                                                                          |
|                                                  | 20-200<br>mg/kg SC,                                                   |                                                                                                  |

|                                      |                                                |                                                                                                   |
|--------------------------------------|------------------------------------------------|---------------------------------------------------------------------------------------------------|
|                                      | IM <sup>2</sup>                                | Guinea pigs/treatment of deficiency                                                               |
|                                      | 50-100 mg/animal PO, SC daily <sup>72</sup>    | Guinea pigs/treatment of deficiency; start parenteral, then PO until resolution of clinical signs |
|                                      | 0.2-0.4 mg/mL drinking water <sup>72</sup>     | Guinea pigs/prevents deficiency; change daily                                                     |
| Vitamin D                            | 200-400 U/kg SC, IM <sup>3</sup>               | All species                                                                                       |
| Vitamin E/selenium (Bo-Se, Schering) | 0.1 mL/100-250 g SC <sup>3</sup>               | All species                                                                                       |
| Vitamin K <sub>1</sub>               | 1-10 mg/kg IM q24h × 4-6 days <sup>33</sup>    | All species/warfarin poisoning; menadiols not used in acute cases                                 |
|                                      | 2.5-5 mg/kg IM q24h × 21-28 days <sup>33</sup> | All species/brodifacoum poisoning; menadiols not used in acute cases                              |

TABLE 8-8 Common and Scientific Names of Rodents.<sup>33</sup>

| Common Name      | Other Common Names                                    | Scientific Name                                       |
|------------------|-------------------------------------------------------|-------------------------------------------------------|
| Chinchilla       | Long-tailed chinchilla                                | <i>Chinchilla laniger</i>                             |
| Chipmunk         | Siberian chipmunk; Korean chipmunk; Japanese squirrel | <i>Tamias sibiricus</i> ( <i>Eutamias sibiricus</i> ) |
| Degu             | Common degu                                           | <i>Octodon degus</i>                                  |
| Duprasi          | Fat-tailed gerbil                                     | <i>Pachyuromys duprasi</i>                            |
| Gerbil           | Mongolian gerbil; clawed jird                         | <i>Meriones unguiculatus</i>                          |
| Guinea pig       | Cavy                                                  | <i>Cavia porcellus</i>                                |
| Hamster, Chinese | Striped hamster                                       | <i>Cricetulus griseus</i>                             |
| Hamster, dwarf   | Russian dwarf hamster                                 | <i>Phodopus sungorus sungorus</i>                     |
| Hamster, golden  | Syrian hamster; common hamster                        | <i>Mesocricetus auratus</i>                           |
| Jird             | Shaw's jird                                           | <i>Meriones shawi</i>                                 |
| Mouse            | Common mouse                                          | <i>Mus musculus</i>                                   |
|                  |                                                       |                                                       |

|             |                          |                             |
|-------------|--------------------------|-----------------------------|
| Prairie dog | Black-tailed prairie dog | <i>Cynomys ludovicianus</i> |
| Rat         | Brown rat                | <i>Rattus norvegicus</i>    |

TABLE 8-9 Hematologic and Serum Biochemical Values of Rodents.[3,18,63,83](#)

| Measurement               | Mouse    | Rat     | Gerbil   | Hamster   | Guinea Pig | Chinchilla | Prairie Dog |
|---------------------------|----------|---------|----------|-----------|------------|------------|-------------|
| PCV (%)                   | 35-40    | 35-45   | 35-45    | 45-50     | 35-45      | 27-54      | 36-54       |
| RBC (10 <sup>6</sup> /μL) | 7-11     | 7-10    | 7-8      | 7-8       | 4-7        | 5.6-8.4    | 5.9-9.4     |
| Hgb (g/dL)                | 10-20    | 12-18   | 14-16    | 16.6-18.6 | 11-17      | 11.8-14.6  | 12.7-19.6   |
| WBC (10 <sup>3</sup> /μL) | 4-12     | 5-23    | 7.5-10.9 | 7-10      | 7-14       | 5.4-15.6   | 1.9-10.1    |
| Neutrophils (%)           | 5-40     | 10-50   | 22       | 18-40     | 20-60      | 39-54      | 43-87       |
| Lymphocytes (%)           | 30-90    | 50-70   | 75       | 56-80     | 30-80      | 45-60      | 8-54        |
| Monocytes (%)             | 0-10     | 0-10    | 0-4      | 2         | 2-20       | 0-5        | 0-12        |
| Eosinophils (%)           | 0-5      | 0-5     | 0-3      | 0-1       | 0-5        | 0-5        | 0-10        |
| Basophils (%)             | 0-1      | 0-1     | 0-1      | 0-1       | 0-1        | 0-1        | 0-2         |
| ALT (U/L)                 | 26-77    | 20-92   | —        | 22-128    | 10-25      | 10-35      | 26-91       |
| ALP (U/L)                 | 45-222   | 16-96   | —        | 99-186    | —          | 6-72       | 25-64       |
| AST (U/L)                 | 54-269   | —       | —        | 28-122    | —          | 96         | 16-53       |
| Bilirubin, total (mg/dL)  | 0.1-0.9  | 0.2-0.6 | 0.2-0.6  | 0.1-0.9   | 0.3-0.9    | 0.6-1.3    | 0.1-0.3     |
| BUN (mg/dL)               | 17-28    | 15-21   | 17-27    | 12-26     | 9-32       | 17-45      | 21-44       |
| Calcium (mg/dL)           | 3.2-8    | 5.3-13  | 3.7-6.2  | 5.3-12    | 7.8-10.5   | 5.6-12.1   | 8.3-10.8    |
| Chloride (mEq/L)          | 82-114   | —       | —        | —         | 98-115     | 108-129    | —           |
| Cholesterol (mg/dL)       | 26-82    | 40-130  | 90-150   | 55-181    | 20-43      | 50-302     | —           |
| Creatinine (mg/dL)        | 0.3-1    | 0.2-0.8 | 0.6-1.4  | 0.4-1     | 0.6-2.2    | 0.4-1.3    | 0.8-2.3     |
| Glucose (mg/dL)           | 62-175   | 50-135  | 50-135   | 37-198    | 60-125     | 109-193    | 120-209     |
| Phosphorus (mg/dL)        | 6-10.4   | 5.8-8.2 | 3.7-7    | 3-9.9     | 5.3        | 4-8        | 3.6-10      |
| Potassium (mEq/L)         | 5.1-10.4 | 5.9     | 3.3-6.3  | 3.9-5.5   | 6.8-8.9    | 3.3-5.7    | 4-5.7       |
| Protein, total (g/dL)     | 3.5-7.2  | 5.6-7.6 | 4.3-12.5 | 5.2-7     | 4.6-6.2    | 3.8-5.6    | 5.8-8.1     |
| Albumin (g/dL)            | 2.5-4.8  | 3.8-4.8 | 1.8-5.5  | 3.5-4.9   | 2.1-3.9    | 2.3-4.1    | 2.4-3.9     |
| Globulin (g/dL)           | 0.6      | 1.8-3   | 1.2-6    | 2.7-4.2   | 1.7-2.6    | 0.9-2.2    | 3.4-4.2     |
| Sodium (mEq/L)            | 112-193  | 135-155 | 141-172  | 128-144   | 146-152    | 142-166    | 144-175     |
| Triglycerides (mg/dL)     | —        | 26-145  | —        | 72-227    | 0-145      | —          | —           |

TABLE 8-10 Biologic and Physiologic Data of Rodents.[2,3,33,49,83](#)

| Species     | Avg wt (g)<br>(male/female) | Avg at Puberty (days)<br>(male/female) | Life Span (yr) | Temperature °C (°F)    | Heart Rate<br>(beats/min) | Respiratory<br>(breaths/min) |
|-------------|-----------------------------|----------------------------------------|----------------|------------------------|---------------------------|------------------------------|
| Chinchilla  | 450-600/550-800             | 240-540/240-540 <sup>a</sup>           | 8-10           | 36.1-37.8 (97-100)     | 100-150                   | 40-80                        |
| Deagu       | 200-300                     | 90-180                                 | 10 (record)    | —                      | —                         | —                            |
| Dupressi    | 60-90                       | 75-105                                 | 3              | —                      | —                         | —                            |
| Gerbil      | 65-100/55-85                | 70-85/65-85                            | 3-4            | 37-38.5 (98.6-101.3)   | 360                       | 90                           |
| Guinea pig  | 900-1200/700-900            | 90-120/60-90                           | 4-5            | 37.2-39.5 (99-103.1)   | 230-380                   | 40-100                       |
| Hamster     | 85-130/95-150               | 70-100/40-70                           | 1.5-2          | 37-38 (98.6-100.4)     | 250-500                   | 35-135                       |
| Mouse       | 20-40/25-40                 | 50/50-60                               | 1.5-3          | 36.5-38 (97.5-100.4)   | 325-780                   | 60-220                       |
| Prairie dog | 1000-2200/500-1500          | 730-995                                | 6-10           | 35.4-39.1 (95.7-102.3) | 83-318                    | 40-60                        |
| Rat         | 450-520/250-300             | 65-110                                 | 2.5-3.5        | 35.9-37.5 (96.6-99.5)  | 250-450                   | 115                          |

<sup>a</sup>Babies born in fall breed 1 yr later.

TABLE 8-11 Blood Volumes of Rodents with Safe-Bleeding Volume Recommendations.<sup>67</sup>

| Species    | Blood Volume (Average) | Safe Venipuncture Volume |
|------------|------------------------|--------------------------|
| Gerbil     | 67 mL/kg               | 0.3 mL/animal            |
| Guinea pig | 75 mL/kg               | 7.7 mL/kg                |
| Hamster    | 78 mL/kg               | 5.5 mL/kg                |
| Mouse      | 79 mL/kg               | 7.7 mL/kg                |
| Rat        | 64 mL/kg               | 5.5 mL/kg                |

TABLE 8-12 Urinalysis Reference Values of Rodents.<sup>a,8-11,45</sup>

| Measurement                | Chinchilla | Gerbil    | Guinea Pig                                                 | Hamster     | Mouse             | Rat                                                                           |
|----------------------------|------------|-----------|------------------------------------------------------------|-------------|-------------------|-------------------------------------------------------------------------------|
| Urine volume<br>(mL/24 hr) | —          | 2-4 drops | 20-25                                                      | 5.1-8.4     | 0.5-2.5           | 13-23 (5.5 mL/100 g/24h)                                                      |
| Specific gravity           | —          | —         | 1.005-1.050 (refractometer)<br>1.000-1.025 (reagent strip) | 1.014-1.060 | 1.034             | 1.022-1.050                                                                   |
| Average pH                 | 8.5        | —         | 6.5-8.5                                                    | 8.5         | 5.01              | 5-7                                                                           |
| Protein<br>(mg/dL)         | —          | —         | Average 525                                                | —           | Males proteinuric | <30                                                                           |
| Parasites                  | —          | —         | Cysts of <i>Klossiella cobaye</i> might be seen            | —           | —                 | <i>Trichosomoides crassicauda</i> (bladder threadworm), larvated ova in urine |

<sup>a</sup>Ranges should be considered as guides; values are likely to vary between groups of animals according to such variables as strain, age, sex, fasting, and methodology.



TABLE 8-13 Reproductive Data for Rodents.[3,10,33,49,83](#)

| Species     | Estrus Length (days) | Gestation (days) | Litter Size | Birth Weight (g) | Age Eyes Open (days) | Weaning Age (days) | Breeding Life | Separate Adults Before Birth |
|-------------|----------------------|------------------|-------------|------------------|----------------------|--------------------|---------------|------------------------------|
| Chinchilla  | 30-50                | 105-115          | 2-3         | 30-50            | birth                | 36-48              | —             | —                            |
| Degu        | —                    | 87-93            | 1-10        | 14               | 2-3                  | 28                 | —             | —                            |
| Dupresi     | —                    | 19-22            | 3-6         | —                | —                    | 21-28              | —             | —                            |
| Gerbil      | 4-6                  | 24-26            | 4-6         | 2.5-3.5          | 16-20                | 20-30              | 15-20 months  | No (mate for life)           |
| Guinea pig  | 15-17                | 59-72            | 2-5         | 60-100           | birth                | 14-28              | 3-4 years     | No                           |
| Hamster     | 4                    | 15-18            | 4-12        | 2                | 14-16                | 20-28              | 11-18 months  | Yes                          |
| Mouse       | 4-5                  | 19-21            | 10-12       | 0.5-1.5          | 10-14                | 21-28              | 12-18 months  | No                           |
| Prairie dog | 14-21                | 30               | 2-10        | —                | —                    | 42-49              | —             | —                            |
| Rat         | 4-5                  | 19-23            | 6-12        | 5-6              | 12-17                | 17-21              | 14 months     | No                           |

TABLE 8-14 Determining the Sex of Mature Rodents.[33,63](#)

| Male                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | Female                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <ul style="list-style-type: none"><li>• Anogenital distance is longer in the male</li><li>• Manipulate “genital papilla” (prepuce) to protrude penis</li><li>• Palpate for testicles either in a scrotal sac (if present) or subcutaneous in inguinal region</li><li>• Males have only two external openings in the inguinal area:<ul style="list-style-type: none"><li>• Anus</li><li>• Urethral orifice at tip of penis</li></ul></li><li>• In very fat males, there may be a depression between the penis and anus; this depression can be obliterated by manipulating the skin in that area</li></ul> | <ul style="list-style-type: none"><li>• Anogenital distance is shorter in the female</li><li>• Look for three external openings in the inguinal area:<ul style="list-style-type: none"><li>• Anus (most caudal opening)</li><li>• Vaginal orifice (middle opening)—look carefully</li><li>• Urethral orifice at tip of urethral papilla (most cranial opening)</li></ul></li><li>• The urethral papilla is located outside the vagina (unlike dogs and cats)</li><li>• In very fat females or young females, the vaginal orifice may be either hidden by folds of skin (the former) or sealed (latter); gentle manipulation of the skin in this area will divulge the orifice</li></ul> |

TABLE 8-15 Nutritional Data for Rodents.[3,34,83](#)

| Species     | Consumption<br>(per 100 g BW/day) |            | Nutritional Recommendations |                        |         |             |
|-------------|-----------------------------------|------------|-----------------------------|------------------------|---------|-------------|
|             | Food (g)                          | Water (mL) | Minimum<br>Fiber (%)        | Carbo-<br>hydrates (%) | Fat (%) | Protein (%) |
| Chinchilla  | 3-6                               | —          | —                           | —                      | —       | —           |
| Gerbil      | 5-8                               | 4-7        | —                           | —                      | 2-4     | 16-22       |
| Guinea pig  | 6                                 | 10         | 16-18                       | 16                     | —       | 18-30       |
| Hamster     | 8-12                              | 8-10       | —                           | 8                      | 3-5     | 15-25       |
| Mouse       | 12-18                             | 15         | —                           | 45-55                  | 5-25    | 16-20       |
| Prairie dog | 2.3-4.1                           | —          | —                           | —                      | —       | —           |
| Rat         | 5-6                               | ≥10-12     | —                           | —                      | 5-25    | 12-27       |

TABLE 8-16 Zoonotic Diseases in Rodents.

| Species                     | Potential Zoonotic Disease                                                                                                                                    |
|-----------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Chinchilla <sup>49</sup>    | <i>Listeria monocytogenes</i>                                                                                                                                 |
|                             | Lymphocytic choriomeningitis (LCM); rare                                                                                                                      |
|                             | Dermatophytes ( <i>Trichophyton mentagrophytes</i> , <i>Microsporum canis</i> , <i>M. gypseum</i> )                                                           |
|                             | <i>Baylisascaris procyonis</i>                                                                                                                                |
| Gerbil <sup>34</sup>        | Salmonellosis; rare                                                                                                                                           |
|                             | <i>Hymenolepis nana</i> ; rare                                                                                                                                |
| Guinea pig <sup>34,46</sup> | Allergies (cutaneous and respiratory) to dander and urinary proteins                                                                                          |
|                             | <i>Bordetella</i> , salmonellosis, <i>Yersinia pseudotuberculosis</i> , <i>Streptococcus</i> ; rare                                                           |
|                             | Dermatophyte ( <i>Trichophyton mentagrophytes</i> )                                                                                                           |
|                             | Sarcoptic mites ( <i>Trixacarus caviae</i> , <i>Sarcoptes scabiei</i> )                                                                                       |
| Hamster <sup>15,34</sup>    | Salmonellosis, <i>Acinetobacter</i>                                                                                                                           |
|                             | Lymphocytic choriomeningitis (LCM); rare                                                                                                                      |
|                             | Dermatophytes ( <i>Trichophyton mentagrophytes</i> , <i>Microsporum</i> spp)                                                                                  |
|                             | <i>Hymenolepis nana</i>                                                                                                                                       |
| Mouse <sup>34</sup>         | Allergies (cutaneous and respiratory) to dander and urinary proteins                                                                                          |
|                             | Salmonellosis; rare                                                                                                                                           |
|                             | Lymphocytic choriomeningitis (LCM); rare                                                                                                                      |
| Prairie dog <sup>49</sup>   | <i>Clostridium piliforme</i> , <i>Pasteurella multocida</i> , salmonellosis, <i>Yersinia pseudotuberculosis</i> , <i>Y. pestis</i> , <i>Y. enterocolitica</i> |
|                             | Hanta virus (wild-caught), rabies virus (wild-caught)                                                                                                         |
|                             | Dermatophytes ( <i>Trichophyton mentagrophytes</i> , <i>Microsporum gypseum</i> )                                                                             |
|                             | Various ectoparasites (mites, fleas, lice)                                                                                                                    |

|                   |                                                                                                                                                                               |
|-------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Rat <sup>34</sup> | Allergies (cutaneous and respiratory) to dander and urinary proteins                                                                                                          |
|                   | Leptospirosis, salmonellosis, cestodiasis, streptococcal infection                                                                                                            |
|                   | Hemorrhagic fever, sylvatic plague (vector: rat fleas), St. Louis encephalitis (vector: <i>Liponyssus sylviarum</i> ), rat bite fever ( <i>Streptobacillus moniliformis</i> ) |

TABLE 8-17 Disease Testing in Rodents<sup>20</sup>

| Laboratory                                                                                                                                                                                                                                                                                            | Test                                                                                                                                                           |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Avecon Diagnostics 501 Grouse Drive Bath, PA 18014, USA 610-837-8400 Email: <a href="mailto:rlstephon@avecon.com">rlstephon@avecon.com</a>                                                                                                                                                            | ELISA for ADV Aleutian disease virus antibody in ferret saliva or blood (serum/plasma)                                                                         |
| Synlab Diagnostic 68161 Mannheim Friedrichsring 4, Germany 011 49 6211 66 72 40 Email: <a href="mailto:Synlabdia@aol.com">Synlabdia@aol.com</a>                                                                                                                                                       | ELISA for ADV Aleutian disease virus antibody in ferret saliva or blood (serum/plasma)                                                                         |
| Avian Biotech International 1336 Timberlane Road Tallahassee, FL 32312, USA 800-514-9672 Email: <a href="mailto:contact@avianbiotech.com">contact@avianbiotech.com</a>                                                                                                                                | PCR for <i>Mycobacterium</i> , <i>Candida</i> , <i>Cryptosporidium</i> , <i>Giardia</i> , <i>Salmonella</i>                                                    |
| Avian Biotech International UK PO Box 107 Truro Cornwall, TR1 2YR, England 011-44-1872-262737 Email: <a href="mailto:contact@avianbiotech.co.uk">contact@avianbiotech.co.uk</a> Website: <a href="http://www.avianbiotech.co.uk">www.avianbiotech.co.uk</a>                                           | PCR for <i>Mycobacterium</i> , <i>Candida</i> , <i>Cryptosporidium</i> , <i>Giardia</i> , <i>Salmonella</i>                                                    |
| Laboratory Animal Diagnostic Services (LADS) BioReliance Corporation 14920 Broschart Road Rockville, MD 20850, USA 800-804-3586 Email: <a href="mailto:lads@bioreliance.com">lads@bioreliance.com</a>                                                                                                 | Rodent and rabbit serology, rodent PCR                                                                                                                         |
| BioReliance Ltd. Todd Campus Glasgow, G20 0XA, Scotland 44 (0)141 946 9999                                                                                                                                                                                                                            | Rodent and rabbit serology, rodent PCR                                                                                                                         |
| Charles River Laboratories International, Inc. 251 Ballardvale Street Wilmington, MA 01887, USA 877-274-8371 (US and Canada) 800 3195 3430 (International)                                                                                                                                            | Serology and PCR for rodents                                                                                                                                   |
| Animal Health Diagnostic Center College of Veterinary Medicine Cornell University 240 Farrier Rd Ithaca, NY 14853, USA 607-253-3900 Web: <a href="http://www.diagcenter.vet.cornell.edu">www.diagcenter.vet.cornell.edu</a> Email: <a href="mailto:diagcenter@cornell.edu">diagcenter@cornell.edu</a> | Serum neutralization and direct fluorescence for canine distemper virus, <i>Giardia</i> and <i>Cryptosporidium</i> antigen ELISA, fungal serology              |
| University of Georgia 110 Riverbend Rd, Riverbend North Athens, GA 30602, USA 706-542-5812 Web: <a href="http://www.vet.uga.edu/SAMS/IDL">www.vet.uga.edu/SAMS/IDL</a>                                                                                                                                | PCR for <i>Salmonella</i> and <i>Pasteurella</i> , serology for <i>Pasteurella</i> , Aleutian disease virus ELISA                                              |
| Michigan State Univeristy Clinical Pathology Laboratory Veterinary Medical Center Michigan State University East Lansing, MI 48824, USA 517-355-1774 Web: <a href="http://www.animalhealth.msu.edu">www.animalhealth.msu.edu</a>                                                                      | PCR for canine disease virus, ferret enteric coronavirus, ferret rotavirus A and C, rabbit rotavirus, rabbit hemorrhagic disease virus, Aleutian disease virus |
|                                                                                                                                                                                                                                                                                                       |                                                                                                                                                                |

|                                                                                                                                                                                                                                                           |                                                                                           |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------|
| University of Missouri-Columbia Research Animal Diagnostic Laboratory (RADIL) 4011 Discovery Drive Columbia, MO 65201, USA 800-669-0825 Email: <a href="mailto:RADIL@missouri.edu">RADIL@missouri.edu</a>                                                 | PCR testing for rodents and serology for rodents and rabbits                              |
| Research Associates Laboratory (R.A.L., Inc.) 14556 Midway Road Dallas, TX 75244, USA 972-960-2221 Web: <a href="http://www.vetdna.com">www.vetdna.com</a>                                                                                                | PCR for <i>Helicobacter</i> , <i>Cryptosporidium</i> , <i>Giardia</i> , <i>Salmonella</i> |
| Taconic Anmed One Hudson City Centre Hudson, NY 12534, USA 888-822-6642 Email: <a href="mailto:custserv@taconic.com">custserv@taconic.com</a> European Customer Services: Email: <a href="mailto:TaconicEurope@taconic.com">TaconicEurope@taconic.com</a> | Serology for rodents and rabbits, PCR for <i>Helicobacter</i>                             |
| University of Miami–Comparative Pathology 1120 NW 14th Street CRB Building Miami, FL 33136, USA 800-596-7390. Email: <a href="mailto:compathlab@med.miami.edu">compathlab@med.miami.edu</a>                                                               | Serology for rodents, <i>Giardia</i> and <i>Cryptosporidium</i> antigen ELISA             |
| Veterinary Molecular Diagnostics 5989 Meijer Dr, Suite 5 Milford, OH 45150, USA 513-576-1808 <a href="http://www.vmdlabs.com">www.vmdlabs.com</a>                                                                                                         | PCR for <i>Helicobacter</i> , <i>Cryptosporidium</i>                                      |
| Zoologix Inc 9811 Owensmouth Avenue, Suite 4 Chatsworth, CA 91311, USA 818-717-8880 Email: <a href="mailto:info@zoologix.com">info@zoologix.com</a>                                                                                                       | Extensive list of avian, primate, wildlife, and rodent PCR tests                          |

TABLE 8-18 Endocrine Values in Rodents.<sup>45</sup>

| Test                                   | Guinea Pig               | Syrian Hamster | Mouse        | Rat              |
|----------------------------------------|--------------------------|----------------|--------------|------------------|
| Free plasma cortisol (µg/dL)           | 0.6-5.8                  | 0.5-1          | —            | —                |
| Salivary cortisol <sup>a</sup> (ng/mL) | Baseline: 6.6 ± 3.4      | —              | —            | —                |
|                                        | Post-ACTH stim: 157 ± 53 | —              | —            | —                |
| Total serum T <sub>4</sub> (µg/dL)     | 2.5 ± 0.3-3.2 ± 0.8      | 3.6            | 3.08-4.74    | 3.4-6.22         |
| Free T <sub>4</sub> (ng/dL)            | 1.26-2.03                | —              | —            | 1.17-2.8         |
| Total T <sub>3</sub> (ng/dL)           | 39-44                    | 45.45          | 84.42-110.39 | —                |
| Free T <sub>3</sub> (ng/dL)            | 0.221-0.26               | —              | 52-77.9      | 110-1038 (pg/dL) |

<sup>a</sup>For ACTH stimulation test, inject 20 U ACTH IM; repeat sample 4 hr postinjection.

TABLE 8-19 Echocardiographic Measurements in Rodents.<sup>38</sup>

| Parameters                                               | Chinchilla | Guinea Pig | Hamster | Mouse     | Rat       |
|----------------------------------------------------------|------------|------------|---------|-----------|-----------|
| Left ventricular internal diameter in diastole (mm)      | 5.1-6.9    | 6.49-7.21  | 3.7-4.5 | 3.48-3.66 | 5.93-6.43 |
| Left ventricular internal diameter in systole (mm)       | 2.3-4.3    | 4.18-4.52  | 1.9-2.7 | 2.26-2.42 | 4.08-4.42 |
| Thickness of left ventricular free wall in diastole (mm) | 2-2.8      | 1.44-2.06  | 0.9-1.1 | 0.41-0.43 | 1.12-1.7  |
| Thickness of left ventricular free wall in systole (mm)  | —          | 1.91-2.61  | —       | 0.86-0.92 | 2.02-2.7  |
| Thickness of interventricular septum in diastole (mm)    | 1.5-2.3    | 1.88-2.68  | 0.9-1.1 | 0.42-0.44 | 1.06-1.36 |
| Thickness of interventricular septum in systole (mm)     | —          | 2.22-3.38  | —       | 0.89-0.93 | 1.4-1.9   |
| Left atrial appendage diameter (mm)                      | 4.3-5.9    | 4.61-5.29  | —       | —         | —         |
| Aortic diameter (mm)                                     | 3.7-6      | 4.4-4.9    | —       | —         | —         |
| Heart rate (beats/min)                                   | 137-201    | —          | 327-417 | —         | —         |

## References

1. Adamcak A, Otten B. Rodent therapeutics. *Vet Clin North Am Exotic Anim Pract.* 2000;3:221–237. viii
2. Allen DG, Pringle JK, Smith DA. Handbook of Veterinary Drugs. JB Lippincott Co: Philadelphia, 1993.
3. Anderson NL. Basic husbandry and medicine of pocket pets. In: Birchard SJ, Sherding RG. *Saunders Manual of Small Animal Practice.* Philadelphia: WB Saunders Co; 1994:1363–1389.
4. ARC Recommended Anesthetics in Rodents.  
[http://www.utsouthwestern.edu/vgn/images/portal/cit\\_56417/5/54/537421ARC\\_R](http://www.utsouthwestern.edu/vgn/images/portal/cit_56417/5/54/537421ARC_R)  
December 16, 2010. Accessed

5. Battles AH. The biology, care and diseases of the Syrian hamster. *Compend Cont Educ Pract Vet*. 1985;7:815–825.
6. Bauck L, Boyer TH, Brown SA, et al. Exotic Animal Formulary. Lakewood, CO: American Animal Hospital Association; 1995:46.
7. Baumans V, Havenaar R, Van Herck H, et al. The effectiveness of Ivomec and Neguvon on the control of murine mites. *Lab Anim*. 1988;22:243–245.
8. Beck W, Pantchev N. *Praktische Parasitologie bei Heimtieren*. Hanover: Schluetersche-Verlagsgesellschaft MBH & Co; 2006.
9. Bihun C, Bauck L. Basic anatomy, physiology, husbandry, and clinical techniques. In: Quesenberry KE, Carpenter JW. *Ferrets, Rabbits, and Rodents: Clinical Medicine and Surgery*. 2nd ed. St Louis: WB Saunders Co; 2004:286–298.
10. Bishop CR. Reproductive medicine of rabbits and rodents. *Vet Clin North Am Exotic Anim Pract*. 2002;5:507–535.
11. Bishop CR, Fischer J, Brossoit A, et al. Standardization of renal physiology parameters in guinea pigs via urinalysis. *Proc Annu Conf Assoc Avian Vet/Assoc Exotic Mam Vet (Specialty Session)*; 2010:49–52.
12. Bistner SI, RB Ford. Kirk's and Bistner's Handbook of Veterinary Procedures and Emergency Treatment. 6th ed. Philadelphia: WB Saunders Co; 1994:844–847.
13. Burgmann P, Percy DH. Antimicrobial drug use in rodents and rabbits. In: Prescott JF, Baggot JD. *Antimicrobial Therapy in Veterinary Medicine*. 2nd ed. Ames: Iowa State University Press; 1993:524–541.
14. Burke TJ. “Wet tail” in hamsters and other diarrheas of small rodents. Bonagura JD, ed. *Kirk's Current Veterinary Therapy XII: Small Animal Practice*. Philadelphia: WB Saunders Co; 1995:1336–1339.
15. Capello V. Pet hamster medicine and surgery—Part III. infectious, parasitic and metabolic diseases. *Exotic DVM*. 2002;3:27–32.

16. Carpenter JW. Personal communication; 2011.
17. Carter KK, Hietala S, Brooks DL, et al. Tylosin concentrations in rat serum and lung tissue after administration in drinking water. *Lab Anim Sci*. 1987;37:468–470.
18. Collins BR. Common diseases and medical management of rodents and lagomorphs. In: Jacobson ER, Kollias GV, Jr. *Exotic Animals*. New York: Churchill Livingstone; 1988:261–316.
19. Collins BR. Antimicrobial drug use in rabbits, rodents, and other small mammals. In: *Antimicrobial Therapy in Caged Birds and Exotic Pets*. Trenton: Veterinary Learning Systems Co; 1995:3–10.
20. Cray C. Novel diagnostics for exotic mammals. Proc Annu Conf Assoc Avian Vet/Assoc Exotic Mam Vet (Specialty Session); 2006:75–82.
21. Cruz JL, Loste JM, Burzaco OH. Observations on the use of medetomidine/ketamine and its reversal with atipamezole for chemical restraint in the mouse. *Lab Anim*. 1998;32:18–22.
22. Donnelly TM. Nasal lesions in gerbils. *Lab Anim*; 1997:17–18. Feb
23. Donnelly TM. Disease problems of chinchillas. In: Quesenberry KE, Carpenter JW. *Ferrets, Rabbits, and Rodents Clinical Medicine and Surgery*. 2nd ed. St Louis: WB Saunders Co; 2004:255–265.
24. Eisele PH. Anesthesia for small mammals. Proc North Am Vet Conf; 1997:785–791.
25. Ewringmann A, Glöckner B. Leitsymptome bei Meerschweinchen, Chinchilla und Degu. Diagnostischer Leitfaden und Therapie. Stuttgart: Enke Publishing; 2005.
26. Ewringmann A, Glöckner B. Leitsymptome bei Hamster, Ratte, Mause und Rennmaus. Diagnostischer Leitfaden und Therapie. Stuttgart: Enke Publishing; 2008.



27. Flecknell PA. Analgesia of small mammals. *Vet Clin North Am Exotic Anim Pract.* 2001;4:47–56.
28. Glen JB. Animal studies of the anesthetic activity of ICI 35 865. *Br J Anaesth.* 1980;56:617–627.
29. Göbel T, Ewringmann A. Heimtierkrankheiten. Kleinsäuger, Amphibien, Reptilien. Stuttgart: UTB Publishing; 2005.
30. Goswick SM, Brenner GM. Activities of azithromycin and amphotericin B against *Naegleria fowleri* in vitro and in a mouse model of primary amebic meningoencephalitis. *Antimicrob Agents Chemother.* 2003;47:524–528.
31. Granson HJ. Gabapentin for tail trauma in a Syrian hamster (*Mesocricetus auratus*). *Proc Annu Conf Assoc Avian Vet/Assoc Exotic Mam Vet (Specialty Session)*; 2010:107–108.
32. Guzman-Silva MA, Pollastri CE, Pantaleão JAS, et al. Tramadol minimizes potential pain during post-oophorectomy in Wistar rats. *Proc 6th World Congr Altern Anim Use Life Sci.* 2007;14:91–92. Tokyo: AATEX
33. Harkness JE. *A Practitioner's Guide to Domestic Rodents*. Lakewood, CO: American Animal Hospital Association; 1993.
34. Harkness JE, Wagner JE. *The Biology and Medicine of Rabbits and Rodents*, 4th ed. Philadelphia: Williams & Wilkins; 1995.
35. Harrenstien L. Critical care of ferrets, rabbits, and rodents. *Semin Avian Exotic Pet Med.* 1994;3:217–228.
36. Hawkins MG, Pascoe PJ. Anesthesia, analgesia, and sedation of small mammals. In: Quesenberry KE, Carpenter JW. *Ferrets, Rabbits, and Rodents: Clinical Medicine and Surgery*. St Louis: Saunders/Elsevier; 2012:429–451.
37. Heard DJ. Principles and techniques of anesthesia and analgesia for exotic practice. *Vet Clin North Am Small Anim Pract.* 1993;23:1301–1327.
38. Heatley JJ. Small exotic mammal cardiovascular disease. *Proc Annu Conf*



Assoc Avian Vet/Assoc Exotic Mam Vet (Specialty Session); 2007:69–78.

39. Hoefer H. Common problems in guinea pigs. *Proc North Am Vet Conf*; 1999:831–832.

40. Hoefer H. Diagnosis and management of chinchilla diseases. *Proc North Am Vet Conf*; 1999:833–835.

41. Hoefer HL. Chinchillas. *Vet Clin North Am Small Anim Pract*. 1994;24:103–111.

42. Hoefer HL. Skin diseases and treatment in small mammals. *Proc North Am Vet Conf*; 2004:1391–1392.

43. Huerkamp MJ. Anesthesia and postoperative management of rabbits and pocket pets. In: Bonagura JD, ed. *Kirk's Current Veterinary Therapy XII: Small Animal Practice*. Philadelphia: WB Saunders Co; 1995:1322–1327.

44. Jenkins JR. Husbandry and common diseases of the chinchilla (*Chinchilla laniger*). *J Small Exotic Anim Med*. 1992;2:15–17.

45. Jepson L. Exotic Animal Medicine. A Quick Reference Guide. New York: WB Saunders Co; 2009:93–173.

46. Johnson-Delaney C. Guinea pigs. In: *Exotic Companion Medicine Handbook for Veterinarians*. Lake Worth, FL: Wingers Publishing; 1996:10–19.

47. Johnson-Delaney C. Prairie dogs. In: *Exotic Companion Medicine Handbook for Veterinarians*. Lake Worth, FL: Wingers Publishing; 1996:17–25.

48. Johnson-Delaney C. Small rodents. In: *Exotic Companion Medicine Handbook for Veterinarians*. Lake Worth, FL: Wingers Publishing; 1996:2–10.

49. Johnson-Delaney C. Special rodents. In: *Exotic Companion Medicine Handbook for Veterinarians*. Lake Worth, FL: Wingers Publishing; 1996:8–35.

50. Johnson-Delaney C. Postoperative management of small mammals. *Exotic DVM*. 1999;1.5:19–21.

51. Klement P, Augustine JM, Delaney KM, et al. An oral ivermectin regimen that eradicates pinworms (*Syphacia* sp.) in rats and mice. *Lab Anim Sci*. 1996;46:286–290.
52. Laird KL, Swindle MM, Flecknell PA. *Handbook of Rodent and Rabbit Medicine*. New York: Pergamon; 1996.
53. Lennox AM. Sedation of exotic companion mammals. Proc Annu Conf Assoc Avian Vet/Assoc Exotic Mam Vet (Specialty Session); 2010:117–120.
54. Levin L. Pain control in laboratory animals. *Sci Anim Care*. 1994;5:1–4.
55. Liles JH, Flecknell PA. A comparison of the effects of buprenorphine, carprofen, and flunixin following laparotomy in rats. *J Vet Pharmacol Therap*. 1994;17:284–290.
56. Mayer J. The use of GnRH to treat cystic ovaries in a guinea pig. *Exotic DVM*. 2003;5.5:36.
57. Mayer J. Personal observation; 2011.
58. Mayer J, Wagner R. Clinical aspects of hyperthyroidism in the guinea pig. Proc Annu Conf Assoc Avian Vet/Assoc Exotic Mam Vet (Specialty Session); 2009:69–73.
59. Mayer J, Sato A, Kiupel M, DeCubellis J, Donnelly T. Use of cabergoline in the treatment of a pituitary adenoma in a rat. *J Am Vet Med Assoc*. 2011;239:656–660.
60. McClure JT, Rosin E. Comparison of amikacin dosing regimens in neutropenic guinea pigs with *Escherichia coli* infection. *Am J Vet Res*. 1998;59:750–755.
61. McCoy J, Jori F, Stem C. Tranquillization of cane rats with a depot neuroleptic. *J Vet Pharmacol Therap*. 1997;20:233–239.
62. Mitchell EB, Zhender A, Hsu A, et al. Pimobendan. treatment of heart failure in small mammals. Proc Annu Conf Assoc Avian Vet/Assoc Exotic Mam Vet

(Specialty Session); 2008:71–79.

63. Mitchell MA, Tully TN, Jr. *Manual of Exotic Pet Practice*. St Louis: Saunders/Elsevier; 2009.

64. Morgan RJ, Eddy LB, Solie TN, et al. Ketamine-acepromazine as an anaesthetic agent for chinchillas (*Chinchilla laniger*). *Lab Anim*. 1981;15:282–283.

65. Morrisey JK. Personal communication; 2004.

66. Morrisey JK, Carpenter JW. Formulary. In: Quesenberry KE, Carpenter JW. *Ferrets, Rabbits, and Rodents: Clinical Medicine and Surgery*. 3rd ed. St Louis: Saunders/Elsevier; 2012:566–575.

67. Ness RD. Rodents. In: Carpenter JW, ed. *Exotic Animal Formulary*. 3rd ed. St Louis: Saunders/Elsevier; 2005:375–408.

68. Ogino K, Hatanaka K, Kawamura M, et al. Evaluation of pharmacological profile of meloxicam as an anti-inflammatory agent, with particular reference to its relative selectivity for cyclooxygenase-2 over cyclooxygenase-1. *Pharmacology*. 1997;55:44–53.

69. Oglesbee B. Emergency medicine of pocket pets. In: Bonagura JD, ed. *Kirk's Current Veterinary Therapy XII: Small Animal Practice*. Philadelphia: WB Saunders Co; 1995:1328–1331.

70. Pollock C. Postoperative management of the exotic animal patient. *Vet Clin North Am Exotic Anim Pract*. 2002;5:183–212.

71. Pollock C. Personal communication; 2004.

72. Quesenberry KE. Guinea pigs. *Vet Clin North Am Small Anim Pract*. 1994;24:67–87.

73. Quesenberry KE. Medical management of gerbils, hamsters, and guinea pigs. *Proc 21st Annu Waltham/OSU Symp*; 1997:51–55.

74. Redrobe S. Imaging techniques in small mammals. *Semin Avian Exotic Pet Med*. 2001;10:187–197.
75. Redrobe S. Soft tissue surgery of rabbits and rodents. *Semin Avian Exotic Pet Med*. 2002;11:231–245.
76. Richardson VCG. *Diseases of Domestic Guinea Pigs*. Oxford: Blackwell Scientific Publications; 1992.
77. Richardson VCG. *Diseases of Small Domestic Rodents*. Malden, MA: Blackwell Scientific Publications; 1997.
78. Schoeb TR. Respiratory diseases of rodents. *Vet Clin North Am Exotic Anim Pract*. 2000;3:481–496.
79. Schuchman SM. Individual care and treatment of rabbits, mice, rats, guinea pigs, hamsters, and gerbils. In: Kirk RW, ed. *Current Veterinary Therapy X: Small Animal Practice*. Philadelphia: WB Saunders Co; 1989:738–765.
80. Schweigart G. *Arzneimittelanwendung bei Nagetieren und Kaninchen Handbücher für die Heimtierpraxis*, 2nd ed. Berlin: Veterinärmedizinischer Fachverlag; 2009.
81. Smith DA, Burgmann PM. Formulary. In: Hillyer EV, Quesenberry KE. *Ferrets, Rabbits, and Rodents: Clinical Medicine and Surgery*. Philadelphia: WB Saunders Co; 1997:392–404.
82. Taffs LF. Further studies on the efficacy of thiabendazole given in the diet of mice infected with *H. nana*, *S. obvelata*, and *A. tetraptera*. *Vet Rec*. 1976;99:143–144.
83. Tell LA. Medical management of prairie dogs. *Proc North Am Vet Conf*. 1995:721–724.
84. Tynes VV. Drug therapy in pet rodents. *Vet Med*; 1998:988–991. (Nov)
85. Walter T, Chan TR, Weichman BM. Effects of analgesics on bradykinin-induced writhing in mice. *Agents Actions*. 1989;27:375–377.

86. Williams BH. Diseases of rodents. Proc North Am Vet Conf; 1995:690–691.

# Chapter 9

## Rabbits

Christine V. Fiorello, Stephen J. Divers

TABLE 9-1 Antimicrobial Agents Used in Rabbits.<sup>a</sup>

| Agent                         | Dosage                                                           | Comments                                                                                            |
|-------------------------------|------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------|
| Amikacin                      | 2-5 mg/kg SC, IM q8-12h <sup>62</sup>                            |                                                                                                     |
|                               | 8-16 mg/kg SC, IM, IV q24h <sup>79</sup>                         | Decreased toxicity when given once daily; for IV use, dilute in 4 mL/kg saline and give over 20 min |
|                               | 10 mg/kg SC, IM q8-12h <sup>6</sup>                              |                                                                                                     |
|                               | 1.25 g/20 g methylmethacrylate <sup>14</sup>                     | Place in bone after surgical debridement of jaw abscess                                             |
| Azithromycin                  | 4-5 mg/kg IM q48h × 7 days <sup>26</sup>                         | Effective against syphilis                                                                          |
|                               | 15-30 mg/kg PO q24h × 15 days <sup>104</sup>                     | PD; appropriate dose for pulmonary infections                                                       |
| Cefazolin                     | 2 g/20 g methylmethacrylate <sup>14</sup>                        | Place in bone after surgical debridement of jaw abscess                                             |
| Cefotaxime                    | 50 mg/kg IM q8h <sup>141</sup>                                   | Pneumococcal endocarditis                                                                           |
| Ceftazidime                   | 50 mg/kg IM, IV q3h <sup>1</sup>                                 | PD                                                                                                  |
|                               | 100 mg/kg IM q12h <sup>182</sup>                                 |                                                                                                     |
| Ceftiofur                     | 2 g/20 g methylmethacrylate <sup>14</sup>                        | Place in bone after surgical debridement of jaw abscess                                             |
| Ceftriaxone (Rocephin, Roche) | 40 mg/kg IM q12h × 2 days <sup>93</sup> or 3 days <sup>141</sup> | Effective against syphilis, <sup>93</sup> pneumococcal endocarditis <sup>141</sup>                  |
| Cephalexin                    | —                                                                | Oral cephalosporins are not recommended <sup>60</sup>                                               |
|                               | 15 mg/kg SC q12h <sup>60</sup>                                   | Parenteral form not available in the United States; not generally recommended                       |
| Cephalothin                   | 12.5 mg/kg IM q6h × 6 days <sup>144</sup>                        | Cephalosporins are generally not recommended; <sup>60</sup> not available in the United States      |
|                               | 2 g/20 g methylmethacrylate <sup>14</sup>                        | Place in bone after surgical debridement of jaw abscess                                             |

|                                                              |                                                    |                                                                                                                                                                                                                                           |
|--------------------------------------------------------------|----------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Chloramphenicol                                              | —                                                  | The use of chloramphenicol in food-producing animals is prohibited in the United States                                                                                                                                                   |
|                                                              | 25 mg/kg PO q8-12h <sup>144</sup>                  |                                                                                                                                                                                                                                           |
|                                                              | 30 mg/kg PO q12h <sup>81</sup>                     |                                                                                                                                                                                                                                           |
|                                                              | 30 mg/kg SC, IM, IV q8-12h <sup>81,144</sup>       |                                                                                                                                                                                                                                           |
|                                                              | 50 mg/kg PO, SC, IM, IV q8h <sup>71</sup>          |                                                                                                                                                                                                                                           |
|                                                              | 55 mg/kg PO q12h × 4 wk <sup>153</sup>             | Effective against syphilis                                                                                                                                                                                                                |
| Chlortetracycline                                            | 50 mg/kg PO q24h <sup>22</sup>                     |                                                                                                                                                                                                                                           |
| Ciprofloxacin <sup>b</sup><br>(Cipro, Bayer; Ciloxan, Alcon) | —                                                  | May cause arthropathies in young animals <sup>158</sup>                                                                                                                                                                                   |
|                                                              | 5-20 mg/kg PO q12h <sup>144</sup>                  | Suspension in water is stable for 14 days                                                                                                                                                                                                 |
|                                                              | 10-20 mg/kg PO q12h <sup>71</sup>                  |                                                                                                                                                                                                                                           |
|                                                              | 1 drop topical q8-12h <sup>58</sup>                | Nasal pasteurellosis; maintains therapeutic levels in tear film for at least 6 hr after application (tears drain into nasal sinus)                                                                                                        |
| Difloxacin <sup>b</sup><br>(Dicural, Fort Dodge)             | 5 mg/kg IM, IV q24h <sup>3</sup>                   | PD; dose appropriate for <i>E. coli</i> infections                                                                                                                                                                                        |
| Doxycycline                                                  | 2.5 mg/kg PO q12h <sup>28</sup>                    |                                                                                                                                                                                                                                           |
|                                                              | 4 mg/kg PO q24h <sup>130</sup>                     |                                                                                                                                                                                                                                           |
| Enrofloxacin <sup>b</sup><br>(Baytril, Bayer)                | —                                                  | May cause arthropathies in young dogs, but similar effects using standard dosages in rabbits have not been reported; SC and IM injections may cause muscle necrosis or sterile abscesses; dilute before giving parenterally <sup>79</sup> |
|                                                              | 5 mg/kg IM, IV q12-24h <sup>44</sup>               | Angora rabbits/PD                                                                                                                                                                                                                         |
|                                                              | 5 mg/kg PO, SC, IM, IV q12h <sup>18,19,23</sup>    | PD; <sup>19,23</sup> clinical trial for pasteurellosis, × 14 days <sup>18</sup>                                                                                                                                                           |
|                                                              | 5-10 mg/kg PO, SC, IM q12h <sup>30</sup>           | Pasteurellosis                                                                                                                                                                                                                            |
|                                                              | 5-20 mg/kg PO, IM q12h × 14-30 days <sup>144</sup> | Pasteurellosis                                                                                                                                                                                                                            |

|                                   |                                                      |                                                                                                                    |
|-----------------------------------|------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------|
|                                   | 200 mg/L drinking water × 14 days <sup>18</sup>      |                                                                                                                    |
| Florfenicol                       | —                                                    | In the United States, use of related drug chloramphenicol is prohibited in food-producing animals                  |
|                                   | 25 mg/kg IM, IV q6h <sup>92</sup>                    | PD                                                                                                                 |
|                                   | 30 mg/kg PO, IV q8h <sup>2</sup>                     | PD                                                                                                                 |
| Furazolidone                      | 5 mg/kg PO q24h × 14 days <sup>22</sup>              |                                                                                                                    |
|                                   | 5.5 g/L drinking water <sup>22</sup>                 |                                                                                                                    |
|                                   | 50 mg/kg feed <sup>22</sup>                          |                                                                                                                    |
| Gentamicin                        | —                                                    | Seldom indicated; use with caution                                                                                 |
|                                   | 4 mg/kg SC, IM q24h <sup>22</sup>                    |                                                                                                                    |
|                                   | 5-8 mg/kg SC, IM, IV q8-24h <sup>79</sup>            | Decreased toxicity when given once daily; for IV use, dilute in 4 mL/kg saline and give over 20 min                |
|                                   | 1 g/20 g methylmethacrylate <sup>14</sup>            | Place in bone after surgical debridement of jaw abscess                                                            |
| Marbofloxacin <sup>b</sup>        | —                                                    | Lowest MIC of nine antibiotics tested against bacteria responsible for upper respiratory infections <sup>152</sup> |
|                                   | 2 mg/kg IM, IV q24h <sup>4</sup>                     | PD study during <i>Pasteurella</i> infection                                                                       |
|                                   | 5 mg/kg PO q24h × 10 days <sup>31</sup>              | PD                                                                                                                 |
| Metronidazole                     | 20 mg/kg PO q12h <sup>30,71</sup>                    |                                                                                                                    |
|                                   | 40 mg/kg PO q24h × 3 days <sup>22</sup>              |                                                                                                                    |
| Minocycline                       | 6 mg/kg IV q8h <sup>125</sup>                        | PD                                                                                                                 |
| Moxifloxacin <sup>b</sup>         | 5 mg/kg PO, IM q24h × 10 days <sup>47</sup>          | Susceptible infections (some bacteria may require higher doses)                                                    |
|                                   | 40 mg/kg IV q12h × 2 doses, then q24h <sup>133</sup> | Bacterial meningitis                                                                                               |
| Netilmicin (Netromycin, Schering) | 6-8 mg/kg SC, IM, IV q24h <sup>160</sup>             | For IV use, dilute and give over 20 min                                                                            |
| Ofloxacin <sup>b</sup>            | 20 mg/kg SC q8h <sup>106</sup>                       | Urogenital, skin, respiratory infections                                                                           |



|                                               |                                                            |                                                                                                                               |
|-----------------------------------------------|------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------|
| (Ocuflox, Allergan)                           |                                                            |                                                                                                                               |
| Oxytetracycline                               | 15 mg/kg IM q8h <sup>108</sup>                             | PD; anorexia and diarrhea at 30 mg/kg IM q8h; tissue irritation can occur                                                     |
|                                               | 25 mg/kg SC q24h <sup>130</sup>                            |                                                                                                                               |
|                                               | 50 mg/kg PO q12h <sup>22</sup>                             |                                                                                                                               |
|                                               | 1 mg/mL drinking water <sup>22</sup>                       |                                                                                                                               |
| Penicillin G                                  | —                                                          | Do not give any form of penicillin orally to rabbits                                                                          |
| • Benzathine form                             | 42,000-60,000 U/kg IM q48h <sup>56</sup>                   | Benzathine penicillin achieves lower serum levels than other forms and is effective against only highly susceptible organisms |
|                                               | 42,000-84,000 U/kg SC q7d × 3 wk <sup>144</sup>            |                                                                                                                               |
| • Procaine form                               | 40,000 U/kg IM q24h × 5-7 days <sup>49</sup>               | Rabbit syphilis                                                                                                               |
|                                               | 42,000-84,000 U/kg SC, IM q24h <sup>56</sup>               |                                                                                                                               |
|                                               | 60,000 U/kg IM q8h <sup>178</sup>                          | PD                                                                                                                            |
| Rifampin (R)/azithromycin (A)                 | (R) 40 mg/kg PO q12h + (A) 50 mg/kg PO q24h <sup>159</sup> | <i>Staphylococcus</i> osteomyelitis                                                                                           |
| Rifampin (R)/clarithromycin (C)               | (R) 40 mg/kg + (C) 80 mg/kg PO q12h <sup>159</sup>         | <i>Staphylococcus</i> osteomyelitis                                                                                           |
| Silver sulfadiazine cream (Silvadene, Marion) | Topical q24h <sup>82</sup>                                 | Does not cause diarrhea if ingested                                                                                           |
| Sulfadimethoxine                              | 10-15 mg/kg PO q12h <sup>62</sup>                          |                                                                                                                               |
| Sulfamethazine                                | 1 mg/mL drinking water <sup>22</sup>                       |                                                                                                                               |
|                                               | 5-10 g/kg feed <sup>22</sup>                               |                                                                                                                               |
| Sulfaquinoxaline                              | 1 mg/mL drinking water <sup>22</sup>                       |                                                                                                                               |
|                                               | 0.6 g/kg feed <sup>22</sup>                                |                                                                                                                               |
| Tetracycline                                  | 50 mg/kg PO q8-12h <sup>22</sup>                           |                                                                                                                               |
|                                               | 50-100 mg/kg PO q8h <sup>144</sup>                         |                                                                                                                               |

|                              |                                                                             |                                                                                                                                                                     |
|------------------------------|-----------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                              | 250-1000 mg/L drinking water <sup>56</sup>                                  | Therapeutic levels not achieved even at 800-1600 mg/L; <sup>139</sup> 250 mg/L not effective in clinical trial for pasteurellosis <sup>130</sup>                    |
| Tilmicosin (Micotil, Elanco) | 12.5 mg/kg PO q24h × 7 days <sup>55</sup>                                   | PD                                                                                                                                                                  |
|                              | 25 mg/kg SC once <sup>110</sup>                                             | Pasteurellosis; use cautiously: at least one rabbit death and several human deaths have been reported; <sup>28</sup> has been associated with anemia and leukopenia |
| Tobramycin (Nebcin, Lilly)   | 1 g/20 g methylmethacrylate <sup>14</sup>                                   | Place in bone after surgical debridement of jaw abscess                                                                                                             |
|                              | 10% in calcium sulfate pellets <sup>123</sup>                               | Biodegradable implants for treatment of osteomyelitis                                                                                                               |
| Trimethoprim/sulfa           | 15 mg/kg PO q12h <sup>22</sup>                                              |                                                                                                                                                                     |
|                              | 30 mg/kg PO, SC, IM q12h <sup>62,81,144</sup>                               | May cause tissue necrosis when given SC <sup>62</sup>                                                                                                               |
| Tylosin (Tylan, Elanco)      | 10 mg/kg PO, SC, IM q12h <sup>22</sup>                                      |                                                                                                                                                                     |
|                              | 10 mg/kg PO, SC, IM q24h <sup>34</sup>                                      |                                                                                                                                                                     |
| Vancomycin                   | 50 mg/kg IV q8h <sup>125</sup>                                              | PD                                                                                                                                                                  |
|                              | 10 mg vancomycin and 50 mg DL-lactide-co-glycolide copolymer <sup>172</sup> | Osteomyelitis; effective locally for 56 days                                                                                                                        |

<sup>a</sup> There is a potential for antibiotic-induced enterotoxemia following administration of some antimicrobial agents (see [Table 9-13](#)). Appetite and fecal character must be monitored closely during and following therapy.

<sup>b</sup> The use of fluoroquinolones in food-producing animals is strictly prohibited in the United States. Do not use these drugs in rabbits that may be consumed by humans.

TABLE 9-2 Antifungal Agents Used in Rabbits.

| Agent        | Dosage                         | Comments                                     |
|--------------|--------------------------------|----------------------------------------------|
| Albaconazole | 5 mg/kg PO q24h <sup>115</sup> | Cryptococcal meningitis                      |
|              |                                | Severe fungal infections; use in combination |

|                                        |                                                          |                                                                                                                                                 |
|----------------------------------------|----------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------|
| Amphotericin B                         | —                                                        | with fluconazole; <sup>155</sup> potentially nephrotoxic and hepatotoxic                                                                        |
| • Desoxycholate form                   | 1 mg/kg IV q24h <sup>155</sup>                           |                                                                                                                                                 |
| • Liposomal form                       | 5 mg/kg IV q24h <sup>140</sup>                           | Invasive aspergillosis                                                                                                                          |
| Clotrimazole (Lotrimin, Schering)      | Topical <sup>64</sup>                                    | Localized dermatophytosis                                                                                                                       |
| Fluconazole                            | 5 mg/kg PO q24h <sup>115</sup>                           | Cryptococcal meningitis                                                                                                                         |
|                                        | 25-43 mg/kg IV (slow) q12h <sup>103</sup>                | Systemic fungal disease                                                                                                                         |
|                                        | 37.5 mg/kg PO q12h <sup>9</sup>                          | <i>Aspergillus</i> keratitis                                                                                                                    |
|                                        | 80 mg/kg PO q24h × 21 days <sup>161</sup>                | Coccidioidal meningitis; controlled but did not cure                                                                                            |
| Griseofulvin                           | 12.5-25 mg/kg PO q12-24h × 30-45 days <sup>82,144</sup>  | Advanced cases of dermatophytosis; decrease dose by 50% if using ultra-microsize form (Gris-PEG, Allergan Herbert), which has better absorption |
| Itraconazole                           | 20 mg/kg PO q24h <sup>175</sup>                          | <i>Aspergillus</i> pneumonia                                                                                                                    |
|                                        | 40 mg/kg PO q24h <sup>137</sup>                          | Invasive aspergillosis                                                                                                                          |
| Ketoconazole                           | 10-40 mg/kg PO q24h × 14 days <sup>62</sup>              | Dermatophytosis                                                                                                                                 |
| Lime sulfur (2-3%)                     | Topical q5-7d × 4 wk <sup>144</sup>                      | Dermatophytosis; use with caution                                                                                                               |
| Micafungin                             | 0.25-2 mg/kg IV q24h <sup>140</sup>                      | Systemic candidiasis                                                                                                                            |
| Miconazole (Conofite, Schering-Plough) | Topical q24h × 14-28 days <sup>62</sup>                  | Localized dermatophytosis                                                                                                                       |
| Miconazole/chlorhexidine shampoo       | Bathe once daily <sup>83</sup>                           | Dermatophytosis                                                                                                                                 |
| Nystatin                               | 20 mg/kg PO q12h × 10 days <sup>70</sup>                 | <i>Cyniclomyces guttulatus</i> yeast overgrowth                                                                                                 |
| Posaconazole                           | 20 mg/kg PO q24h <sup>175</sup>                          | <i>Aspergillus</i> pneumonia                                                                                                                    |
| Terbinafine                            | —                                                        | Best used as part of combination therapy; little activity when used as a single agent <sup>90,161</sup>                                         |
|                                        | 100 mg/kg PO q12h × 21 days <sup>161</sup>               | Less effective than fluconazole for coccidioidal meningitis                                                                                     |
|                                        | 100 mg/kg PO q24h in combination with amphotericin B 0.4 | Invasive aspergillosis                                                                                                                          |

TABLE 9-3 Antiparasitic Agents Used in Rabbits.

| Agent                                                         | Dosage                                                       | Comments                                                                                             |
|---------------------------------------------------------------|--------------------------------------------------------------|------------------------------------------------------------------------------------------------------|
| Albendazole                                                   | 7.5-20 mg/kg PO q24h <sup>21</sup> × 3-14 days <sup>60</sup> | Potential treatment for encephalitozoonosis; use cautiously, deaths have anecdotically been reported |
| Amprolium (9.6%)                                              | 0.5 mL/pint drinking water × 10 days <sup>62,71</sup>        | Coccidiosis                                                                                          |
|                                                               | 5 mL/gal drinking water × 21 days <sup>144</sup>             |                                                                                                      |
| Carbaryl powder 5%                                            | Topically q7d <sup>120</sup>                                 | Ectoparasites; use sparingly                                                                         |
| Cyromazine 6% (Rearguard, Novartis)                           | Topically q6-10wk <sup>83</sup>                              | Preventative for myiasis                                                                             |
| Decoquinate (Deccox, Rhone-Poulenc)                           | 62.5 ppm in feed <sup>62</sup>                               | Coccidiosis                                                                                          |
|                                                               | 72-200 ppm in feed <sup>114</sup>                            |                                                                                                      |
| Diclazuril                                                    | 4 mg/kg SC <sup>136</sup>                                    |                                                                                                      |
|                                                               | 1 ppm in feed <sup>62,173</sup>                              | Coccidiosis                                                                                          |
| Doramectin                                                    | 0.2 mg/kg IM once <sup>84</sup>                              | <i>Psoroptes</i> mites                                                                               |
|                                                               | 0.3 mg/kg SC <sup>57</sup>                                   | PD                                                                                                   |
| Emodepside 2.1%/praziquantel 8.6% (Profender, Bayer)          | 0.14 mL/kg topically once <sup>113</sup>                     | <i>Trichostrongylus colubriformis</i>                                                                |
| Eprinomectin                                                  | 0.2-0.3 mg/kg SC once <sup>135</sup>                         | <i>Psoroptes</i> mites                                                                               |
|                                                               | 2 mg/kg topically once <sup>179</sup>                        | <i>Psoroptes</i> mites                                                                               |
| Febantel/pyrantel embonate/praziquantel (Drontal Plus, Bayer) | ½ tablet/5 kg PO once <sup>113</sup>                         | Use tablet for puppies and small dogs (2-25 lb); effective against nematodes and cestodes            |
| Fenbendazole                                                  | —                                                            | On rare occasions, anemia and arteritis have been reported. <sup>a</sup>                             |
|                                                               | 5 mg/kg PO <sup>130</sup>                                    |                                                                                                      |
|                                                               | 5-20 mg/kg PO q24h × 5 days;                                 | Nematodes; use 20 mg/kg for                                                                          |

|                                                          |                                                                                                                     |                                                                  |
|----------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------|
|                                                          | repeat in 14 days <sup><a href="#">113</a></sup>                                                                    | <i>Passalurus ambiguous</i>                                      |
|                                                          | 10 mg/kg q24h PO, repeat in 14 days prn <sup><a href="#">71</a></sup>                                               |                                                                  |
|                                                          | 20 mg/kg PO q24h for 7 days before and 2 days after mixing rabbits <sup><a href="#">165</a></sup>                   | Preventative against encephalitozoonosis                         |
|                                                          | 20 mg/kg PO q24h × 28 days <sup><a href="#">165</a></sup>                                                           | Treatment for encephalitozoonosis; failed to clear all parasites |
|                                                          | 50 ppm in feed × 2-6 wk <sup><a href="#">129</a></sup>                                                              |                                                                  |
| Fipronil (Frontline, Merial)                             | Contraindicated <sup><a href="#">118</a></sup>                                                                      | Can cause neurologic disease and death                           |
| Imidacloprid (Advantage, Bayer)                          | 10-16 mg/kg (single 0.4 mL dose, 10% solution) as a single topical application <sup><a href="#">60,76,120</a></sup> | Flea adulticide                                                  |
| Imidacloprid (I) 10%/moxidectin (M) 1% (Advocate, Bayer) | 10 mg/kg (I) + 1 mg/kg (M) topically q4wk × 3 treatments <sup><a href="#">83</a></sup>                              | <i>Psoroptes</i> mites                                           |
| Imidacloprid 8.8%/permethrin 44% (Advantix, Bayer)       | 11-16.6 mg/kg topically once <sup><a href="#">15</a></sup>                                                          | <i>Leporacarus gibbus</i> (rabbit fur mite)                      |
| Ivermectin                                               | —                                                                                                                   | Ectoparasites                                                    |
|                                                          | 0.1-0.2 mg/kg SC, repeat in 14 days <sup><a href="#">17</a></sup>                                                   | Ear mites, clinical trial                                        |
|                                                          | 0.2-0.4 mg/kg SC q10-14d <sup><a href="#">120</a></sup>                                                             |                                                                  |
|                                                          | 0.4 mg/kg PO, SC q7-14d <sup><a href="#">71</a></sup>                                                               |                                                                  |
|                                                          | 0.4 mg/kg SC q7d × 2-3 wk <sup><a href="#">144</a></sup>                                                            |                                                                  |
|                                                          | 0.4 mg/kg SC q80h × 3 doses <sup><a href="#">85</a></sup>                                                           | Sarcoptic mange                                                  |
|                                                          | 0.6 mg/kg SC q14d <sup><a href="#">118</a></sup>                                                                    |                                                                  |
| Lasalocid                                                | 120 ppm in feed <sup><a href="#">62</a></sup>                                                                       | Coccidiosis                                                      |

|                               |                                                                                                  |                                                                                                                                                                      |
|-------------------------------|--------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Lime sulfur (2-3%)            | 1-2 dips/wk × 28 days <sup><a href="#">144</a></sup>                                             | Ectoparasites; young animals                                                                                                                                         |
|                               | Dip q7d × 4-6 wk <sup><a href="#">120,144</a></sup>                                              |                                                                                                                                                                      |
| Lufenuron (Program, Novartis) | 30 mg/kg PO q30d <sup><a href="#">118</a></sup>                                                  | Flea larvicide                                                                                                                                                       |
| Metronidazole                 | 20 mg/kg PO q12h <sup><a href="#">120</a></sup>                                                  | Antiprotozoal agent                                                                                                                                                  |
| Monensin (CoBan 60, Elanco)   | 0.002-0.004% in feed <sup><a href="#">62</a></sup>                                               | Coccidiosis                                                                                                                                                          |
| Moxidectin                    | 0.2 mg/kg PO, repeat in 10 days <sup><a href="#">174</a></sup>                                   | Psoroptic mange                                                                                                                                                      |
|                               | 0.3 mg/kg SC <sup><a href="#">57</a></sup>                                                       | PD                                                                                                                                                                   |
| Oxibendazole                  | 30 mg/kg PO q24h × 7-14 days, then 15 mg/kg PO q24h for 30-60 days <sup><a href="#">28</a></sup> | Encephalitozoonosis; no highly effective treatment has been identified; anecdotal bone marrow suppression has been reported, so an intratreatment CBC is recommended |
| Piperazine                    | 200 mg/kg PO, repeat in 14-21 days <sup><a href="#">71,144</a></sup>                             | Use with citrate formulation                                                                                                                                         |
|                               | 500 mg/kg PO × 2 days <sup><a href="#">96</a></sup>                                              | Adults; use with adipate formulation                                                                                                                                 |
|                               | 750 mg/kg PO × 2 days <sup><a href="#">96</a></sup>                                              | Juveniles                                                                                                                                                            |
|                               | 2-5 mg/mL drinking water × 7 days <sup><a href="#">71</a></sup>                                  |                                                                                                                                                                      |
| Praziquantel (Droncit, Bayer) | 5-10 mg/kg PO, SC, IM, repeat in 10 days <sup><a href="#">6</a></sup>                            | Cestodes, trematodes                                                                                                                                                 |
|                               | 10 mg/kg PO once <sup><a href="#">113</a></sup>                                                  | Cestodes                                                                                                                                                             |
| Pyrantel pamoate              | 5-10 mg/kg PO, SC, IM, repeat in 10 days <sup><a href="#">120</a></sup>                          |                                                                                                                                                                      |
|                               | 5-10 mg/kg PO, repeat in 14-21 days <sup><a href="#">144</a></sup>                               |                                                                                                                                                                      |

|                                 |                                                                                    |                                                                                                                                                                 |
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| Pyrethrins                      | Topically as directed for puppies/kittens q7d <sup><a href="#">118,120</a></sup>   | Flea control                                                                                                                                                    |
| Rofenaid (Rofenaid 40, Roche)   | 62.5-250 ppm in feed <sup><a href="#">62</a></sup>                                 | Coccidiosis                                                                                                                                                     |
| Selamectin (Revolution, Pfizer) | 12 mg/kg topically at base of neck once <sup><a href="#">89</a></sup>              | Cheyletiellosis                                                                                                                                                 |
|                                 | 20 mg/kg topically q7d <sup><a href="#">29</a></sup>                               | PD/flea infestation; further studies are needed to assess long-term safety in rabbits at this dose following repeated application <sup><a href="#">29</a></sup> |
|                                 | 30 mg (8-14 mg/kg) topically q30 days × 2 doses <sup><a href="#">46,98</a></sup>   | Sarcoptic mange                                                                                                                                                 |
|                                 | 30 mg (6-18 mg/kg) topically once <sup><a href="#">98,112</a></sup>                | <i>Psoroptes</i> mites                                                                                                                                          |
| Sulfadimethoxine                | 50 mg/kg PO once, then 25 mg/kg q24h × 10-20 days <sup><a href="#">62,71</a></sup> | Coccidiosis                                                                                                                                                     |
| Sulfadimidene                   | 100-233 mg/L drinking water <sup><a href="#">60</a></sup>                          | Coccidiosis                                                                                                                                                     |
| Sulfamerazine                   | 100 mg/kg PO <sup><a href="#">56</a></sup>                                         | Coccidiosis                                                                                                                                                     |
|                                 | 0.05-0.15% in drinking water <sup><a href="#">56</a></sup>                         |                                                                                                                                                                 |
| Sulfamethazine                  | 100 mg/kg PO q24h <sup><a href="#">56</a></sup>                                    | Coccidiosis                                                                                                                                                     |
|                                 | 0.77 g/L drinking water <sup><a href="#">56</a></sup>                              |                                                                                                                                                                 |
|                                 | 0.5-1% in feed <sup><a href="#">56</a></sup>                                       |                                                                                                                                                                 |
| Sulfamethoxine                  | 50 mg/kg PO once, then 25 mg/kg PO q24h × 10-20 days <sup><a href="#">20</a></sup> | Coccidiosis                                                                                                                                                     |
| Sulfaquinoxaline                | 0.02-0.05% in drinking water <sup><a href="#">56</a></sup>                         | Coccidiosis/prevention                                                                                                                                          |
|                                 | 0.025-0.1% in                                                                      | Alternating 2 wk periods for 4-8 wk                                                                                                                             |

|                                                                |                                                                                                        |                                                                               |
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|                                                                | drinking water <sup>144</sup><br>0.04-0.1% in<br>drinking water <sup>62</sup>                          | during weaning<br>Coccidiosis                                                 |
|                                                                | 0.1-0.15% in<br>drinking water <sup>56</sup>                                                           | Coccidiosis/treatment                                                         |
|                                                                | 1 mg/mL in<br>drinking water <sup>120</sup>                                                            |                                                                               |
|                                                                | 0.025-0.03% in<br>feed × 4-6 wk <sup>144</sup>                                                         | During weaning                                                                |
|                                                                | 125-250 ppm in<br>feed <sup>62</sup>                                                                   |                                                                               |
| Thiabendazole                                                  | 25-50 mg/kg PO <sup>56</sup>                                                                           |                                                                               |
|                                                                | 50-100 mg/kg PO<br>q24h × 5 days <sup>6</sup>                                                          |                                                                               |
|                                                                | 0.1% in feed × 3<br>mo <sup>130</sup>                                                                  |                                                                               |
| Thiabendazole/dexamethasone/neomycin<br>(Tresaderm, MSD-AgVet) | 3 drops in each ear<br>q12h × 7-14 days <sup>30</sup>                                                  | Use concurrently with ivermectin<br>therapy for ear mites                     |
| Toltrazuril                                                    | 2.5-5 mg/kg PO <sup>149</sup>                                                                          | Intestinal coccidiosis                                                        |
|                                                                | 10 mg/kg PO <sup>73,88</sup>                                                                           | PD; <sup>88</sup> coccidiosis due to <i>Eimeria<br/>tenella</i> <sup>73</sup> |
|                                                                | 25 ppm in drinking<br>water (or 25 mg/kg<br>PO) q24h × 2 days,<br>repeat after 5<br>days <sup>60</sup> | Coccidiosis                                                                   |
|                                                                | 50 ppm in drinking<br>water <sup>24</sup>                                                              | Hepatic coccidiosis due to <i>Eimeria<br/>stiedae</i>                         |

<sup>a</sup> J. Graham, M. M. Garner. Personal communication, 2012.

TABLE 9-4 Chemical Restraint/Anesthetic/Analgesic Agents Used in Rabbits.

| Agent        | Dosage                                  | Comments                                             |
|--------------|-----------------------------------------|------------------------------------------------------|
| Acepromazine | —                                       | See ketamine, ketamine/xylazine for combinations     |
|              | 0.25-1 mg/kg IM <sup>62,67,82,180</sup> | Preanesthetic; sedative; tranquilizer                |
|              | 1-5 mg/kg SC, IM <sup>56</sup>          | Preanesthetic; lower end of dose range is preferred  |
|              | —                                       | Short-term use only; use with caution <sup>105</sup> |



|                                    |                                                                                                                                                   |                                                                                                           |
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| Acetaminophen<br>(Tylenol, McNeil) | 200-500 mg/kg PO <sup><a href="#">56</a></sup>                                                                                                    | Analgesia                                                                                                 |
|                                    | 1-2 mg/mL drinking water <sup><a href="#">74</a></sup>                                                                                            |                                                                                                           |
| Acetaminophen/codeine              | 1 mL elixir/100 mL drinking water <sup><a href="#">180</a></sup>                                                                                  | Analgesia                                                                                                 |
| Acetylsalicylic acid<br>(aspirin)  | 10-100 mg/kg PO q8-12h <sup><a href="#">120</a></sup><br>100 mg/kg PO q8-24h <sup><a href="#">52.81</a></sup>                                     | Antiinflammatory                                                                                          |
|                                    | 100 mg/kg PO q48h <sup><a href="#">62</a></sup>                                                                                                   |                                                                                                           |
| Alfentanil (Alfenta, Taylor)       | 0.03-0.07 mg/kg IV <sup><a href="#">180</a></sup>                                                                                                 | Intraoperative analgesia for 45 min duration                                                              |
| Atipamezole<br>(Antisedan, Pfizer) | Give same volume SC, IV, IP as medetomidine or dexmedetomidine (5× medetomidine or 10× dexmedetomidine dose in mg) <sup><a href="#">120</a></sup> | Medetomidine and dexmedetomidine reversal <sup><a href="#">50</a></sup>                                   |
| Atracurium                         | 0.1 mg/kg IV <sup><a href="#">164</a></sup>                                                                                                       | Paralysis for intraophthalmic surgery; requires assisted ventilation                                      |
| Atropine                           | —                                                                                                                                                 | Many rabbits possess serum atropinase, hence very high doses are often administered                       |
|                                    | 0.1-0.5 mg/kg SC, IM <sup><a href="#">120</a></sup>                                                                                               |                                                                                                           |
|                                    | 0.1-3 mg/kg SC <sup><a href="#">62</a></sup>                                                                                                      |                                                                                                           |
|                                    | 0.8-1 mg/kg IM <sup><a href="#">66</a></sup>                                                                                                      |                                                                                                           |
| Bupivacaine 0.125%                 | 1 mg/kg <sup><a href="#">28</a></sup>                                                                                                             | Epidural anesthesia; dilute with preservative-free saline only; total volume should not exceed 0.33 mL/kg |
| Buprenorphine                      | 0.01-0.05 mg/kg SC, IV, IP q6-12h <sup><a href="#">52.62</a></sup>                                                                                | Analgesia                                                                                                 |
|                                    | 0.012 mg/kg <sup><a href="#">28</a></sup>                                                                                                         | Epidural anesthesia; dilute with preservative-free saline only; total volume should not exceed 0.33 mL/kg |
|                                    | 0.02-0.1 mg/kg SC, IV <sup><a href="#">81</a></sup>                                                                                               |                                                                                                           |
|                                    | 0.03 mg/kg SC 1 hr prior to anesthetic induction <sup><a href="#">122</a></sup>                                                                   | Premedication                                                                                             |
|                                    | 0.03 mg/kg IM q12h <sup><a href="#">35</a></sup>                                                                                                  | Postoperative analgesia                                                                                   |
|                                    | 0.5 mg/kg per rectum                                                                                                                              |                                                                                                           |

|                                                                                           |                                                            |                                                                        |
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|                                                                                           | q12h <sup>74</sup>                                         |                                                                        |
| Butorphanol                                                                               | —                                                          | See ketamine/xylazine for combination; butorphanol combination follows |
|                                                                                           | 0.1-0.5 mg/kg SC, IM, IV q4h <sup>52,67,81</sup>           | Analgesia                                                              |
|                                                                                           | 0.1-1 mg/kg SC, IM, IV q4-6h <sup>120</sup>                |                                                                        |
|                                                                                           | 1-5 mg/kg SC q4-6h <sup>13</sup>                           | Lower dose preferred <sup>28</sup>                                     |
| Butorphanol (B)/midazolam (Mi)                                                            | (B) 0.3-0.5 mg/kg + (Mi) 0.1-0.5 mg/kg IM <sup>48</sup>    | Sedation or premedication                                              |
| Carprofen (Rimadyl, Pfizer)                                                               | —                                                          | Nonsteroidal antiinflammatory; chronic joint pain                      |
|                                                                                           | 1-2.2 mg/kg PO q12h <sup>120</sup>                         |                                                                        |
|                                                                                           | 1.5 mg/kg PO q12h <sup>60,67</sup>                         |                                                                        |
|                                                                                           | 2.2 mg/kg PO q12h <sup>138</sup>                           |                                                                        |
|                                                                                           | 2-4 mg/kg SC q24h <sup>60</sup>                            |                                                                        |
|                                                                                           | 4 mg/kg SC, IM q24h <sup>67</sup>                          |                                                                        |
| Chlorpromazine                                                                            | 1-10 mg/kg IM, IV <sup>56</sup>                            | Preanesthetic; lower end of dose range is generally preferred          |
| Dexmedetomidine <sup>a</sup> (Dexdomitor, Orion)                                          | —                                                          | $\alpha_2$ agonist similar to medetomidine <sup>a</sup>                |
| Diazepam                                                                                  | —                                                          | See ketamine for combinations                                          |
|                                                                                           | 1-3 mg/kg IM <sup>62</sup>                                 | Preanesthetic; tranquilizer                                            |
|                                                                                           | 1-5 mg/kg IM, <sup>30</sup> IV <sup>56,67</sup>            | Preanesthetic; tranquilizer                                            |
|                                                                                           | 1 mg/kg intracavernous <sup>41</sup>                       | Seizures; alternative to IV route                                      |
| Enflurane                                                                                 | To effect <sup>40</sup>                                    | Anesthesia; MAC = 2.9%                                                 |
| Fentanyl                                                                                  | —                                                          | Fentanyl combinations follow; see medetomidine for combination         |
|                                                                                           | 0.0074 mg/kg IV <sup>101</sup>                             |                                                                        |
|                                                                                           | 30-100 mcg/kg/min constant rate infusion <sup>25</sup>     | Analgesia                                                              |
| Fentanyl patch                                                                            | ½ patch/medium-sized rabbit (3 kg) × 3 days <sup>148</sup> | Postoperative analgesia; do not cut patch; cover portion not in use    |
|                                                                                           | 25 mcg patch × 3 days <sup>53</sup>                        | Note: rapid hair regrowth decreases plasma concentrations              |
| Fentanyl (F)/droperidol (D) (0.05 mg [F] plus 2.5 mg [D]); (Innovar-Vet, Schering-Plough) | 0.15-0.44 mL/kg IM <sup>180</sup>                          | 0.22 mL/kg optimal; may cause muscle necrosis at injection site        |

|                                         |                                                                         |                                                                                                                                                                                                             |
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| Fentanyl/fluanisone (Hypnorm, Janssen)  | 0.2-0.3 mL/kg <sup>60</sup>                                             | Premedication; analgesia; sedation                                                                                                                                                                          |
| Flumazenil                              | 0.01-0.1 mg/kg IM, IV <sup>25</sup>                                     | Reversal for benzodiazepines                                                                                                                                                                                |
| Flunixin meglumine (Banamine, Schering) | —                                                                       | Analgesia; nonsteroidal anti-inflammatory <sup>117</sup>                                                                                                                                                    |
|                                         | 0.3-2 mg/kg PO, IM, IV q12-24h <sup>138</sup>                           | Use for no more than 3 days                                                                                                                                                                                 |
|                                         | 1.1 mg/kg SC, IM q12h <sup>52,81</sup>                                  |                                                                                                                                                                                                             |
|                                         | 1-2 mg/kg SC q12-24h <sup>66</sup>                                      |                                                                                                                                                                                                             |
| Gabapentin (Neurontin, Pfizer)          | Dosages for rabbits have not been established                           | Indicated for adjunctive treatment of chronic or neurogenic pain in dogs and cats at 3 mg/kg PO q24h and for ancillary therapy of refractory seizures in dogs and cats at 10-30 mg/kg PO q8h <sup>142</sup> |
|                                         | 25 mg/kg SC <sup>95</sup>                                               | Dose used to approximate plasma concentrations in humans                                                                                                                                                    |
| Glycopyrrolate (Robinul-V, Fort Dodge)  | 0.01-0.02 mg/kg SC <sup>74</sup><br>0.01-0.1 mg/kg SC, IM <sup>25</sup> | Premedication<br>Premedication to prevent salivation and bradycardia                                                                                                                                        |
| Hydromorphone                           | 0.05-0.2 mg/kg SC, IM q6-8h <sup>28</sup>                               | Analgesia                                                                                                                                                                                                   |
| Ibuprofen                               | —                                                                       | Analgesia; nonsteroidal antiinflammatory; may have gastrointestinal side effects                                                                                                                            |
|                                         | 2-7.5 mg/kg PO q4h <sup>120</sup>                                       |                                                                                                                                                                                                             |
|                                         | 7.5 mg/kg PO q6-8h <sup>160</sup>                                       |                                                                                                                                                                                                             |
| Isoflurane                              | 3-5% induction, 1.5-1.75% maintenance <sup>56</sup>                     | Inhalant anesthetic of choice; MAC = 2.05%                                                                                                                                                                  |
|                                         | 3-5% induction, 2-3% maintenance <sup>62</sup>                          |                                                                                                                                                                                                             |
| Ketamine                                | —                                                                       | Ketamine combinations follow; should be administered in combination with other agents                                                                                                                       |
|                                         | 15-20 mg/kg IV <sup>56</sup>                                            |                                                                                                                                                                                                             |
|                                         | 20-50 mg/kg IM <sup>56</sup>                                            | 60 min of sedation                                                                                                                                                                                          |
|                                         | 35-50 mg/kg IM <sup>180</sup>                                           |                                                                                                                                                                                                             |
| Ketamine (K)/acepromazine (A)           | (K) 25-40 mg/kg +(A) 0.25-1 mg/kg IM, IV <sup>67</sup>                  | Anesthesia                                                                                                                                                                                                  |

|                                                             |                                                                                                    |                                                                                                                                                            |
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|                                                             | (K) 40 mg/kg + (A) 0.5-1 mg/kg IM <sup><a href="#">81</a></sup>                                    | Anesthesia                                                                                                                                                 |
| Ketamine (K)/diazepam (D)                                   | (K) 10 mg/kg + (D) 0.5 mg/kg IV <sup><a href="#">119</a></sup>                                     | Anesthesia; follow with isoflurane                                                                                                                         |
|                                                             | (D) 0.2-0.5 mg/kg IV, then (K) 10-15 mg/kg IV to effect <sup><a href="#">66</a></sup>              | Sedation; use with isoflurane for anesthesia                                                                                                               |
|                                                             | (K) 15 mg/kg + (D) 0.3 mg/kg IM <sup><a href="#">116</a></sup>                                     | Anesthesia; follow with isoflurane                                                                                                                         |
|                                                             | (K) 20-30 mg/kg IM, then (D) 0.5 mg/kg IV at 5-10 min <sup><a href="#">71</a></sup>                | Anesthesia; generally used with isoflurane; dentistry (with or without isoflurane)                                                                         |
|                                                             | (K) 20-30 mg/kg + (D) 1-3 mg/kg IM <sup><a href="#">71</a></sup>                                   | Anesthesia; use with isoflurane                                                                                                                            |
|                                                             | (K) 20-40 mg/kg + (D) 1-5 mg/kg IM <sup><a href="#">67</a></sup>                                   |                                                                                                                                                            |
|                                                             | (K) 30-40 mg/kg + (D) 2-5 mg/kg IM <sup><a href="#">30</a></sup>                                   | Surgical anesthesia; lower end of dose range for (D) is preferred; <sup><a href="#">147</a></sup> less preferable than aforementioned (K)/(D) combinations |
| Ketamine (K)/medetomidine (Me) <sup><a href="#">a</a></sup> | (K) 15 mg/kg + (Me) 0.25 mg/kg SC, <sup><a href="#">132</a></sup> IM <sup><a href="#">59</a></sup> | Anesthetic induction; laryngospasm common                                                                                                                  |
|                                                             | (Me) 0.35 mg/kg IM + (K) 5 mg/kg IV <sup><a href="#">68</a></sup>                                  | Surgical anesthesia                                                                                                                                        |
| Ketamine (K)/midazolam (Mi)                                 | (K) 25 mg/kg + (Mi) 2-5 mg/kg IM <sup><a href="#">129</a></sup>                                    | May be preferable to use (Mi) at <2 mg/kg <sup><a href="#">28</a></sup>                                                                                    |
|                                                             | (K) 15 mg/kg IM + (Mi) 3 mg/kg IM <sup><a href="#">59</a></sup>                                    | Anesthetic induction                                                                                                                                       |
| Ketamine (K)/xylazine (X)                                   | —                                                                                                  | Anesthesia; may result in bradycardia; less preferable than (K)/(D)/isoflurane combinations; seldom indicated                                              |
|                                                             | (K) 10 mg/kg + (X) 3 mg/kg IV <sup><a href="#">51,81</a></sup>                                     |                                                                                                                                                            |
|                                                             | (K) 30-40 mg/kg + (X) 3-5 mg/kg IM <sup><a href="#">56</a></sup>                                   |                                                                                                                                                            |
|                                                             | (K) 35 mg/kg + (X) 5 mg/kg IM <sup><a href="#">100</a></sup>                                       |                                                                                                                                                            |
| Ketamine (K)/xylazine (X)/acepromazine (A)                  | (K) 35 mg/kg + (X) 5 mg/kg + (A) 0.75 mg/kg IM <sup><a href="#">100</a></sup>                      | Anesthesia; may result in bradycardia; less preferable than (K)/(D)/isoflurane combinations; seldom indicated                                              |
|                                                             |                                                                                                    |                                                                                                                                                            |

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| Ketamine (K)/xylazine (X)/butorphanol (B)                   | (K) 35 mg/kg + (X) 5 mg/kg + (B) 0.1 mg/kg IM <sup>107</sup>    | Anesthesia; may result in bradycardia; less preferable than (K)/(D)/isoflurane combinations; seldom indicated                                                                         |
| Ketoprofen (Ketofen, Fort Dodge)                            | 1 mg/kg IM q12-24h <sup>138</sup>                               | Musculoskeletal pain; nonsteroidal antiinflammatory                                                                                                                                   |
|                                                             | 3 mg/kg SC, IM q24h <sup>67</sup>                               |                                                                                                                                                                                       |
| Ketoprofen 2.5% topical gel (Menarini, France)              | Apply topically q6-12h <sup>8</sup>                             | Musculoskeletal pain                                                                                                                                                                  |
| Lidocaine                                                   | —                                                               | Local, topical, and epidural anesthesia                                                                                                                                               |
| • 1.5%                                                      | 0.4 mL/kg epidural <sup>151</sup>                               | Epidural anesthesia                                                                                                                                                                   |
| • 10%                                                       | Topical to glottis <sup>74</sup>                                | Facilitates intubation                                                                                                                                                                |
| Medetomidine (Me) <sup>a</sup> /fentanyl (F)/midazolam (Mi) | (Me) 0.2 mg/kg + (F) 0.02 mg/kg + (Mi) 1 mg/kg IM <sup>69</sup> | Anesthesia; endotracheal intubation and supplemental oxygen are required                                                                                                              |
| Medetomidine (Me) <sup>a</sup> /propofol (P)                | (Me) 0.35 mg/kg IM + (P) 3 mg/kg IV <sup>68</sup>               | Surgical anesthesia; note high medetomidine dose <sup>50</sup>                                                                                                                        |
| Meloxicam (Metacam, Boehringer Ingelheim Vetmedica)         | —                                                               | Nonsteroidal antiinflammatory; analgesia; antipyretic; used for osteoarthritis and postoperative pain; palatable PO form                                                              |
|                                                             | 0.2 mg/kg SC, IM q24h <sup>67</sup>                             |                                                                                                                                                                                       |
|                                                             | 0.3 mg/kg PO q24h × 10 days <sup>32</sup>                       | PD/a higher dose (≥0.5 mg/kg) <sup>28</sup> may be required, but efficacy and safety studies have not been performed <sup>32</sup>                                                    |
|                                                             | 0.3 mg/kg PO q24h <sup>67</sup>                                 |                                                                                                                                                                                       |
|                                                             | 0.3-1.5 mg/kg PO q24h × 5 days <sup>170</sup>                   | PD/the higher dose was based on a limited sample size, but efficacy and safety studies have not been performed <sup>170</sup>                                                         |
| Meperidine (Demerol, Winthrop-Breon)                        | 5-10 mg/kg SC, IP q2-3h <sup>62</sup>                           | Analgesia                                                                                                                                                                             |
|                                                             | 5-25 mg/kg SC, IM, IV <sup>56</sup>                             |                                                                                                                                                                                       |
|                                                             | 10 mg/kg SC, IM q2-3h <sup>52,67</sup>                          | Analgesia                                                                                                                                                                             |
|                                                             | 0.2 mg/mL drinking water <sup>74</sup>                          |                                                                                                                                                                                       |
|                                                             | —                                                               | See ketamine, butorphanol, and medetomidine for combinations; more potent, shorter action than diazepam; water soluble; rapidly absorbed and less painful than diazepam when given IM |
|                                                             |                                                                 |                                                                                                                                                                                       |
|                                                             |                                                                 |                                                                                                                                                                                       |

|                                |                                                               |                                                                                                                                                                                                                                                            |
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| Midazolam (Versed, Roche)      | 0.5-2 mg/kg IM, IV, IP <sup><a href="#">102</a></sup>         | Preanesthetic; tranquilizer                                                                                                                                                                                                                                |
|                                | 1-2 mg/kg IM, IV, IP <sup><a href="#">62,82,120</a></sup>     | Preanesthetic; tranquilizer                                                                                                                                                                                                                                |
| Morphine                       | 0.1 mg/kg <sup><a href="#">28</a></sup>                       | Epidural anesthesia; dilute with preservative-free saline only; total volume should not exceed 0.33 mL/kg                                                                                                                                                  |
|                                | 1.2-5 mg/kg SC, IM q2-4h <sup><a href="#">180</a></sup>       | Analgesia                                                                                                                                                                                                                                                  |
|                                | 2-5 mg/kg SC, IM q2-4h <sup><a href="#">52,67,81</a></sup>    |                                                                                                                                                                                                                                                            |
|                                | 5-10 mg/kg SC, IM q4h <sup><a href="#">56</a></sup>           |                                                                                                                                                                                                                                                            |
| Nalbuphine (Nubain, Dupont)    | 1-2 mg/kg IM, IV q4-5h <sup><a href="#">66</a></sup>          | Analgesia                                                                                                                                                                                                                                                  |
| Nalorphine                     | 1-5 mg/kg IV <sup><a href="#">56</a></sup>                    | Narcotic reversal                                                                                                                                                                                                                                          |
| Naloxone                       | 0.01-0.1 mg/kg IM, IV <sup><a href="#">56</a></sup>           | Narcotic reversal; note that analgesic effects are also reversed; avoid use following painful procedure as sudden awareness of pain may predispose to breath-holding, increased catecholamine release, and fatal arrhythmias <sup><a href="#">25</a></sup> |
| Oxymorphone                    | 0.05-0.2 mg/kg SC, IM q8-12h <sup><a href="#">66,67</a></sup> | Analgesia                                                                                                                                                                                                                                                  |
| Pentazocine (Talwin-V, Upjohn) | 5-10 mg/kg IM, IV q2-4h <sup><a href="#">180</a></sup>        | Analgesia                                                                                                                                                                                                                                                  |
| Pentobarbital                  | 20-45 mg/kg IV, IP <sup><a href="#">62</a></sup>              | Marginal analgesia; autonomic depression; not recommended                                                                                                                                                                                                  |
| Piroxicam (Feldene, Pfizer)    | 0.2 mg/kg PO q8h <sup><a href="#">74,117</a></sup>            | Analgesia; nonsteroidal antiinflammatory                                                                                                                                                                                                                   |
| Promazine                      | 1-2 mg/kg IM, IV <sup><a href="#">56</a></sup>                | Preanesthetic                                                                                                                                                                                                                                              |
| Propofol                       | —                                                             | See medetomidine for combination                                                                                                                                                                                                                           |
|                                | 2-3 mg/kg IV <sup><a href="#">129</a></sup>                   | Induction after premedication; maintain with approximately 1 mg/kg IV q15min                                                                                                                                                                               |
|                                | 3-6 mg/kg IV <sup><a href="#">67</a></sup>                    |                                                                                                                                                                                                                                                            |
|                                | 7.5-15 mg/kg IV <sup><a href="#">33</a></sup>                 |                                                                                                                                                                                                                                                            |
|                                | 16 ± 5 mg/kg IV <sup><a href="#">7</a></sup>                  | Anesthetic induction                                                                                                                                                                                                                                       |
| Sevoflurane                    | To effect <sup><a href="#">7</a></sup>                        | Anesthesia; MAC = 3.7% <sup><a href="#">156</a></sup>                                                                                                                                                                                                      |
| Thiamylal                      | 15-25 mg/kg IV to effect <sup><a href="#">180</a></sup>       |                                                                                                                                                                                                                                                            |
| Thiopental                     | 15-30 mg/kg IV to                                             |                                                                                                                                                                                                                                                            |

|                                            |                                                   |                                                                                                                                                                                           |
|--------------------------------------------|---------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Tiletamine/zolazepam (Telazol, Fort Dodge) | effect <sup>180</sup><br>3 mg/kg IM <sup>62</sup> | Sedation prior to gas anesthetic; tiletamine causes severe renal tubular necrosis at 32 mg/kg and mild nephrosis at 7.5 mg/kg; <sup>38</sup> not generally recommended for use in rabbits |
| Tramadol                                   | 4.4 mg/kg IV <sup>42</sup>                        | Did not result in isoflurane-sparing effects                                                                                                                                              |
|                                            | 11 mg/kg PO <sup>162</sup>                        | PD; did not achieve adequate plasma concentrations based on human levels                                                                                                                  |
| Xylazine                                   | —                                                 | See ketamine for combinations                                                                                                                                                             |
|                                            | 1-5 mg/kg SC, IM <sup>43</sup>                    | Preanesthetic; tranquilizer; lower end of dose range preferred; seldom indicated                                                                                                          |
| Yohimbine (Yobine, Lloyd)                  | 0.2-1 mg/kg IM, IV <sup>56</sup>                  | Xylazine reversal                                                                                                                                                                         |

<sup>a</sup> Medetomidine is no longer commercially available although it can be obtained from select compounding services; dosages are listed here as a guide for possible use with dexmedetomidine, an alpha-2 agonist that is the active optical enantiomer of racemic compound medetomidine; it is used at ½ the dose of medetomidine but the same volume due to higher concentration. Although the same effects would be expected as with medetomidine, there is limited data on the efficacy and safety of dexmedetomidine in rabbits, and, to date, appears to have been seldom used clinically in rabbits; the effects of the v/v use of the two drugs may not be equivalent, so the dose of dexmedetomidine may need to be adjusted based on clinical response.

TABLE 9-5 Ophthalmologic Agents Used in Rabbits.

| Agent                                                 | Dosage                                                                       | Comments                                              |
|-------------------------------------------------------|------------------------------------------------------------------------------|-------------------------------------------------------|
| Amphotericin B (liposomal form) (A)/moxifloxacin (Mo) | (A) 10 mcg in 0.05 mL + (Mo) 100 mcg in 0.05 mL intravitreally <sup>37</sup> | (Mo) strongly augments efficacy of (A)                |
| Atropine 1%                                           | Topical to eyes q12h prn <sup>86</sup>                                       | Mydriasis; systemic effects are possible              |
| Atropine 1%/phenylephrine 10%                         | Topical to eyes <sup>62</sup>                                                | Mydriasis for non-albino eyes                         |
| Azithromycin 1%                                       | Topical to eyes q12h × 2 days, then q24h × 5 days <sup>5</sup>               | Bacterial conjunctivitis                              |
| Besifloxacin 0.6% (Besivance, Bausch & Lomb)          | Topical to eyes q12h <sup>143</sup>                                          | Bacterial conjunctivitis; minimal systemic absorption |
| Betaxolol 0.5% (Betoptic,                             | Topical to eyes q12h <sup>87</sup>                                           | Glaucoma; effectively decreases                       |



|                                                              |                                                                                                                        |                                                                                                             |
|--------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------|
| Alcon)                                                       |                                                                                                                        | intraocular pressure in rabbits                                                                             |
| Ciprofloxacin 0.3% (Ciloxan, Alcon)                          | Topical to eyes q8-12h <sup><a href="#">86</a></sup><br>2 drops topical q1h for 7-14 hr <sup><a href="#">134</a></sup> | Susceptible infections<br><br>Ocular penetration injuries, good penetration into aqueous and vitreous humor |
| Cyanoacrylate adhesive (Vetbond, 3M)                         | Topical to corneal ulcer <sup><a href="#">131</a></sup>                                                                | Treatment of corneal ulcers; causes minimal inflammation                                                    |
| Cyclosporine A 0.05% (Restasis, Allergan)                    | Topical to eyes q12h <sup><a href="#">168</a></sup>                                                                    | Dry eye due to autoimmune dacryoadenitis                                                                    |
| Cyclosporine A 0.2% (Optimmune, Schering-Plough)             | Topical to eyes q12h <sup><a href="#">169</a></sup>                                                                    | Shown to increase tear production in rabbits                                                                |
| Dichlorophenamide (Daranide, Merck)                          | 1-2 mg/kg PO q24h <sup><a href="#">91</a></sup>                                                                        | Glaucoma                                                                                                    |
| Diclofenac sodium 0.1%                                       | Topical to eyes <sup><a href="#">176</a></sup>                                                                         | Nonsteroidal antiinflammatory                                                                               |
| Dorzolamide (Trusopt, Merck)                                 | Topical to eyes q8-12 <sup><a href="#">86</a></sup>                                                                    | Glaucoma                                                                                                    |
| Flurbiprofen sodium 0.03%                                    | Topical to eyes <sup><a href="#">94</a></sup>                                                                          | Nonsteroidal antiinflammatory                                                                               |
| Fusidic acid (Fucithalmic, Leo)                              | Topical to eyes q12-24h <sup><a href="#">60</a></sup>                                                                  | Bacterial conjunctivitis                                                                                    |
| Gatifloxacin 0.3% (Zymar, Allergan)                          | Topical to eyes q8h <sup><a href="#">143</a></sup>                                                                     | Bacterial conjunctivitis                                                                                    |
| Gentamicin (Tiacil, Virbac)                                  | Topical to eyes q8h <sup><a href="#">60</a></sup>                                                                      | Bacterial conjunctivitis                                                                                    |
| Granulocyte macrophage colony stimulating factor (rhuGM-CSF) | Topical to eyes, 1 drop q6h <sup><a href="#">16</a></sup>                                                              | Superficial corneal wounds; use 4.8% solution (16 µg rhuGM-CSF in 33 µL saline buffered to pH 7.4)          |
| Ketorolac tromethamine 0.1%                                  | Topical to eyes <sup><a href="#">176</a></sup>                                                                         | Nonsteroidal antiinflammatory                                                                               |
| Lacritin                                                     | Topical to eyes q8-24h × 14 days <sup><a href="#">154</a></sup>                                                        | Dry eyes; resulted in increased basal tearing compared to cyclosporine                                      |
| Metipranolol 0.1%/pilocarpine 2%                             | Topical to eyes q8-12h <sup><a href="#">39</a></sup>                                                                   | Glaucoma                                                                                                    |
| Moxifloxacin 0.5% (Vigamox, Alcon)                           | Topical to eyes q6h <sup><a href="#">109,127</a></sup>                                                                 | Bacterial conjunctivitis                                                                                    |
| Micafungin 0.1%                                              | 0.5 mL subconjunctivally q24h × 3 wk <sup><a href="#">72</a></sup>                                                     | <i>Candida</i> keratitis                                                                                    |
| Neomycin/bacitracin/polymyxin B                              | Topical to eyes q6h <sup><a href="#">86</a></sup>                                                                      | Susceptible infections; corneal ulceration                                                                  |
| Phenylephrine 10%                                            | —                                                                                                                      | See atropine for combination                                                                                |
|                                                              | Topical to eyes <sup><a href="#">78</a></sup>                                                                          | Mydriasis                                                                                                   |
| Prednisolone acetate 1%                                      |                                                                                                                        | Inflammation of eyes; rabbits are a                                                                         |



|                                |                                            |                                                                                           |
|--------------------------------|--------------------------------------------|-------------------------------------------------------------------------------------------|
| ophthalmic solution            | Topical to eyes q6-12h <sup>86</sup>       | corticosteroid-sensitive species; <sup>79</sup> use with extreme caution                  |
| Timolol 0.5% (Timoptic, Merck) | Topical to eyes q12h <sup>87</sup>         | Glaucoma                                                                                  |
| Tissue plasminogen activator   | 25 µg intraocular injection <sup>164</sup> | Intraocular fibrin                                                                        |
| Tropicamide 1%                 | Topical to eyes <sup>62</sup>              | Mydriasis                                                                                 |
| Trovafloxacin 0.5%             | Topical to eyes <sup>10,124</sup>          | Broad-spectrum; <sup>10</sup> safe for intravitreal injection up to 25 mcg <sup>124</sup> |

TABLE 9-6 Miscellaneous Agents Used in Rabbits.

| Agent                                                                    | Dosage                                                     | Comments                                                                                                                                                                       |
|--------------------------------------------------------------------------|------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Activated charcoal (1 g/5 mL water)                                      | 1 g/kg PO q4-6h <sup>77,128</sup>                          | May reduce intestinal absorption of toxins                                                                                                                                     |
| Aluminum hydroxide                                                       | 30-60 mg/kg PO q8-12h <sup>21</sup>                        | Phosphorus-binder; hyperphosphatemia due to renal failure                                                                                                                      |
| Barium                                                                   | 10-14 mL/kg PO <sup>144</sup>                              | Gastrointestinal contrast studies                                                                                                                                              |
| Benazepril                                                               | 0.25-0.5 mg/kg PO q24h <sup>120</sup>                      | Vasodilator; less nephrotoxic than enalapril                                                                                                                                   |
| Blood transfusion (whole blood)                                          | 10-20 mL/kg given no faster than 22 mL/kg/h <sup>102</sup> | Cross-matching advised, especially for repeated transfusions                                                                                                                   |
| Calcium EDTA (edetate calcium disodium) (Calcium Disodium Versenate, 3M) | 13-27 mg/kg SC, IV <sup>60</sup>                           | Chelation therapy                                                                                                                                                              |
|                                                                          | 27 mg/kg SC q6-12h prn <sup>120,166</sup>                  | Lead toxicosis; diluted to <10 mg/mL with 0.45% NaCl/2.5% dextrose                                                                                                             |
| Cellulose powder (Unifiber, Niche)                                       | ½-1 tsp/feeding <sup>145</sup>                             | Nonsoluble fiber source for rabbits on liquid enteral diets; will pass through small diameter feeding tubes                                                                    |
| Chlorphenamine maleate                                                   | 0.2-0.4 mg/kg PO q12h <sup>60</sup>                        | Antihistamine                                                                                                                                                                  |
| Cholestyramine (Questran Light, Squibb)                                  | 2 g/animal PO q24h × 18-21 days <sup>62</sup>              | Ion exchange resin for toxin absorption following inappropriate antibiotic administration; use for treating enterotoxemia; gavage with 20 mL water; may result in constipation |
| Chondroitin sulfate (Cosequin, Nutramax)                                 | Used empirically at feline dose <sup>171</sup>             | Arthritis; a nutraceutical                                                                                                                                                     |
| Cimetidine                                                               | 5-10 mg/kg PO, SC, IM, IV q6-12h <sup>6,83</sup>           | Gastric and duodenal ulcers                                                                                                                                                    |

|                                               |                                                                                                     |                                                                                                                                                                                                            |
|-----------------------------------------------|-----------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Cisapride<br>(Propulsid, Janssen)             | 0.5 mg/kg PO q8-12h <sup>71</sup>                                                                   | Enhances gastrointestinal motility                                                                                                                                                                         |
| Cyclizine                                     | 8 mg/rabbit PO q12h <sup>60</sup>                                                                   | Torticollis                                                                                                                                                                                                |
| Dexamethasone                                 | —                                                                                                   | Corticosteroids are seldom indicated in rabbits; rabbits are a corticosteroid-sensitive species; <sup>79</sup> use with extreme caution and consider concurrent administration of a gastroprotective agent |
|                                               |                                                                                                     |                                                                                                                                                                                                            |
|                                               | 0.2-0.6 mg/kg SC, IM, IV <sup>56</sup>                                                              | Antiinflammatory                                                                                                                                                                                           |
|                                               | 0.5-2 mg/kg PO, SC, then taper dose q12h × 3-14 days <sup>61</sup>                                  |                                                                                                                                                                                                            |
|                                               | 2 mg/kg IM, IV <sup>30</sup>                                                                        | Shock; effectiveness is controversial                                                                                                                                                                      |
| Digoxin                                       | 0.005-0.01 mg/kg PO q12-24h <sup>120</sup>                                                          | Congestive heart failure; atrial fibrillation                                                                                                                                                              |
| Diltiazem                                     | 0.5-1 mg/kg PO q12-24h <sup>120</sup>                                                               | Calcium channel blocker for hypertrophic cardiomyopathy                                                                                                                                                    |
| Diphenhydramine                               | 2 mg/kg PO, SC q8-12h <sup>120</sup>                                                                | Torticollis                                                                                                                                                                                                |
| Doxapram                                      | 2-5 mg/kg SC, IV q15min <sup>74</sup>                                                               | Respiratory stimulant                                                                                                                                                                                      |
| Enalapril                                     | 0.1-0.5 mg/kg PO q24-48h <sup>83</sup>                                                              | Beware of hypotensive side effects                                                                                                                                                                         |
| Epinephrine                                   | 0.2 mg/kg IV <sup>147</sup>                                                                         | Cardiac arrest                                                                                                                                                                                             |
|                                               | 0.2-0.4 mg/kg intratracheally <sup>147</sup>                                                        | Cardiac arrest                                                                                                                                                                                             |
| Epoetin alpha, recombinant<br>(Epogen, Amgen) | 50-150 U/kg SC q2-3d <sup>21</sup>                                                                  | Biosynthetic form of erythropoietin; treatment of anemia; use until PCV is normal, then q7d for at least 4 wk                                                                                              |
| Famotidine                                    | 0.5 mg/kg PO, SC, IV q12h <sup>48</sup>                                                             |                                                                                                                                                                                                            |
| Fecal transfaunation                          | Mix fresh cecotrophs with warm saline, strain through gauze, and administer by gavage <sup>74</sup> | Dysbiosis; placement of E-collar on donor facilitates collection of sample                                                                                                                                 |
| Ferrous sulfate                               | 4-6 mg/kg PO q24h <sup>21</sup>                                                                     | Iron deficiency anemia                                                                                                                                                                                     |
| Furosemide                                    | —                                                                                                   | Loop diuretic                                                                                                                                                                                              |
|                                               | 0.3-2 mg/kg SC, IM,                                                                                 |                                                                                                                                                                                                            |

|                                    |                                                                                                               |                                                                                                 |
|------------------------------------|---------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------|
|                                    | IV <sup>60</sup> prn                                                                                          |                                                                                                 |
|                                    | 1-3 mg/kg PO q8-24h <sup>120</sup> prn                                                                        |                                                                                                 |
|                                    | 1-4 mg/kg SC, IM, IV q4-6h <sup>63,120</sup> prn                                                              |                                                                                                 |
|                                    | 2-5 mg/kg PO, SC, IM, IV q12h <sup>120</sup> prn                                                              |                                                                                                 |
| Hetastarch (Hespan, DuPont)        | 5 mL/kg IV given over 5-10 min; repeat if necessary <sup>102</sup>                                            | Volume expansion in hypoproteinemic patients; may be of benefit in endotoxemia                  |
|                                    | 20 mL/kg IV <sup>126</sup>                                                                                    |                                                                                                 |
| Human chorionic gonadotropin (hCG) | 20-25 U/animal IV <sup>62</sup>                                                                               | Ovulation                                                                                       |
| Hydroxyzine                        | 2 mg/kg PO q8-12h <sup>120</sup>                                                                              | Antihistamine; antipruritic                                                                     |
| Iron dextran                       | 4-6 mg/kg IM once <sup>120</sup>                                                                              | Iron deficiency anemia (treatment or prevention)                                                |
| Lactated Ringer's solution         | 60-90 mL/kg <sup>12</sup><br><br>100-150 mL/kg/day constant rate infusion or divided SC q6-12h <sup>102</sup> | Treatment for shock<br><br>Maintenance fluid support                                            |
| Lactobacilli                       | —                                                                                                             | May aid in treatment of enteritis; <sup>144</sup> efficacy not determined                       |
|                                    | Administer PO during antibiotic treatment period, then 5-7 days beyond cessation <sup>34</sup>                | Give 2 hr before or 2 hr after antibiotic treatment                                             |
| Levetiracetam (Keppra, UCB)        | 20 mg/kg PO q8h <sup>11</sup>                                                                                 | Anticonvulsant; dosage not established in rabbits, but PD are similar to those in dogs          |
| Lidocaine                          | 1-2 mg/kg IV (bolus) <sup>148</sup>                                                                           | Cardiac arrhythmia                                                                              |
|                                    | 2-4 mg/kg intratracheally <sup>148</sup>                                                                      | Cardiac arrhythmia                                                                              |
| Loperamide                         | 0.1 mg/kg PO q8h × 3 days, then q24h × 2 days <sup>62</sup>                                                   | Enteropathies (nonspecific diarrhea); give in 1 mL water                                        |
| Meclizine (Antivert, Roering)      | 2-12 mg/kg PO q24h <sup>62</sup>                                                                              | Reduces disorientation and rolling with torticollis (prevents motion sickness in small animals) |
|                                    |                                                                                                               |                                                                                                 |

|                                                    |                                                                               |                                                                                                                  |
|----------------------------------------------------|-------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------|
|                                                    | 12.5-25 mg/kg PO q8-12h <sup>82</sup>                                         |                                                                                                                  |
| Metoclopramide                                     | 0.2-0.5 mg/kg PO, SC q6-8h <sup>71</sup>                                      | Stimulates gastrointestinal motility                                                                             |
|                                                    | 0.2-1 mg/kg PO, SC q6-8h <sup>62</sup>                                        |                                                                                                                  |
|                                                    | 0.5 mg/kg PO, SC q4-12h <sup>82</sup>                                         |                                                                                                                  |
| Mirtazapine                                        | 0.3-0.5 mg/kg PO q24h <sup>146</sup>                                          | Appetite stimulant; dosage not established in rabbits; cat dose given here                                       |
| Nandrolone (Deca-Durabolin, Organon)               | 2 mg/kg SC, IM <sup>60</sup>                                                  | Anabolic steroid; appetite stimulant; adjunct to treatment for anemia, especially in chronic renal failure       |
| Omeprazole                                         | 20 mg/kg SC q12h <sup>99</sup>                                                | Gastroprotective agent                                                                                           |
| Oxytocin                                           | 0.1-3 U/kg SC, IM <sup>60,62</sup>                                            | Use in delayed, but unobstructed, parturition; agalactia                                                         |
| Pimobendan                                         | 0.1-0.3 mg/kg PO q12-24h <sup>120</sup>                                       | Phosphodiesterase inhibitor; increases cardiac contractility with dilated cardiomyopathy or mitral valve disease |
| Polysulfated glycosaminoglycan (Adequan, Luitpold) | 2.2 mg/kg SC, IM q3d × 21-28 days, then q14d <sup>82</sup>                    | Noninfectious, traumatic, or degenerative joint disease                                                          |
| Potassium citrate                                  | 33 mg/kg q8h <sup>180</sup>                                                   | Urinary calculi; may decrease calcium-based stone formation                                                      |
| Prednisolone                                       | —                                                                             | See dexamethasone for comments                                                                                   |
|                                                    | 0.25-0.5 mg/kg PO q12h × 3 days, then q24h × 3 days, then q48h <sup>144</sup> | Treatment of nonresponsive torticollis, when negative for pasteurellosis; give antibiotics concurrently          |
|                                                    | 0.5-2 mg/kg PO q12h <sup>120</sup>                                            |                                                                                                                  |
| Prednisone                                         | —                                                                             | See dexamethasone for comments                                                                                   |
|                                                    | 0.5-2 mg/kg PO <sup>6,30</sup>                                                | Antiinflammatory                                                                                                 |
| Prochlorperazine (Compazine, SmithKline Beecham)   | 0.2-0.5 mg/kg PO q8h <sup>60</sup>                                            | Torticollis; doses as high of 30 mg/kg q8h are used to treat labyrinthine disorders in humans                    |
| Ranitidine (Zantac, Glaxo Wellcome)                | 2 mg/kg IV q24h <sup>60</sup><br>2-5 mg/kg PO q12h <sup>60</sup>              | Gastric ulceration (often in inappetant rabbits)                                                                 |

|                                               |                                                                                        |                                                                                                                                                                                                                               |
|-----------------------------------------------|----------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Sevelamer                                     | Dosages not established in animals; human dosage is 2-4 capsules PO q8h <sup>142</sup> | Phosphorus binder for hyperphosphatemia associated with chronic renal failure; consider monitoring coagulation parameters, as vitamin K absorption may be affected; drug is not absorbed systemically so toxicity is unlikely |
| Silymarin (milk thistle)                      | 4-15 mg/kg PO q8-12h <sup>83</sup>                                                     | Nutraceutical used as an adjunctive treatment for liver disease; hepatoprotectant; dosage not established for rabbits; suggested dose for small animals                                                                       |
|                                               | 20-50 mg/kg PO q24h <sup>142</sup>                                                     |                                                                                                                                                                                                                               |
| Simethicone (Mylanta, Johnson & Johnson)      | 65-130 mg/animal PO q1h × 2-3 treatments <sup>97</sup>                                 | May reduce abdominal discomfort associated with excess gas                                                                                                                                                                    |
| Sodium bicarbonate                            | 2 mEq/kg IV, IP <sup>63</sup>                                                          | Ketoacidosis (pregnancy toxemia); dose is approximate                                                                                                                                                                         |
| Stanozolol (Winstrol-V, Upjohn)               | 1-2 mg PO once <sup>62</sup>                                                           | Stimulates appetite following surgery or illness                                                                                                                                                                              |
| Succimer (DMSA)                               | 1050 mg/m <sup>2</sup> PO × 1 wk, then 700 mg/m <sup>2</sup> × 2 wk <sup>181</sup>     | Lead toxicity                                                                                                                                                                                                                 |
| Sucralfate (Carafate, Hoechst Marion Roussel) | 25 mg/kg PO q8-12h <sup>62</sup>                                                       | Gastrointestinal ulcers; may interfere with other orally administered drugs                                                                                                                                                   |
| Sulfasalazine (Azulfidine, Pharmacia)         | ½-¼ crushed 500 mg tablet/animal q8-24h <sup>97</sup>                                  | May reduce inflammation of intestinal mucosa                                                                                                                                                                                  |
| Verapamil (Isoptin, Knoll)                    | 2.5-25 µg/kg/h IP <sup>163</sup>                                                       | Postoperative administration decreases adhesion formation                                                                                                                                                                     |
|                                               | 0.2 mg/kg SC q8h × 9 treatments <sup>60,62,82</sup>                                    | Slow-channel calcium blocking agent                                                                                                                                                                                           |
| Vitamin A                                     | 500-1000 U/kg IM <sup>120</sup>                                                        |                                                                                                                                                                                                                               |
| Vitamin C (ascorbic acid)                     | 100 mg/kg PO q12h <sup>20</sup>                                                        | Nutritional supplement                                                                                                                                                                                                        |
| Vitamin K                                     | 1-10 mg/kg IM prn <sup>160</sup>                                                       | Select bleeding disorders and toxicities                                                                                                                                                                                      |

TABLE 9-7 Hematologic and Serum Biochemical Values of Rabbits.<sup>45,60,71,81</sup>

| Measurement       | Normal Values |
|-------------------|---------------|
| <b>Hematology</b> |               |
| PCV (%)           | 30-50         |
| Hgb (g/dL)        | 8-17.5        |

|                                 |           |
|---------------------------------|-----------|
| RBC (10 <sup>6</sup> /μL)       | 4-8       |
| MCV (fL)                        | 58-75     |
| MCH (pg)                        | 17.5-23.5 |
| MCHC (g/dL)                     | 29-37     |
| Reticulocytes (%)               | 2-4       |
| Platelets (10 <sup>3</sup> /μL) | 290-650   |
| WBC (10 <sup>3</sup> /μL)       | 5-12      |
| Heterophils (neutrophils) (%)   | 35-55     |
| Lymphocytes (%)                 | 25-60     |
| Monocytes (%)                   | 2-10      |
| Eosinophils (%)                 | 0-5       |
| Basophils (%)                   | 2-8       |
| <b>Chemistries</b>              |           |
| ALP (U/L)                       | 4-70      |
| ALT (U/L)                       | 14-80     |
| Amylase (U/L)                   | 200-500   |
| AST (U/L)                       | 14-113    |
| Bicarbonate (mEq/L)             | 16.2-31.8 |
| Bile acids (μmol/L)             | <40       |
| Bilirubin, total (mg/dL)        | 0-0.75    |
| Calcium (mg/dL)                 | 8-14.8    |
| Chloride (mEq/L)                | 92-112    |
| Cholesterol (mg/dL)             | 12-116    |
| Creatinine (mg/dL)              | 0.5-2.6   |
| Glucose (mg/dL)                 | 75-150    |
| LDH (U/L)                       | 34-129    |
| Lipids, total (mg/dL)           | 280-350   |
| Phosphorus (mg/dL)              | 2.3-6.9   |
| Potassium (mEq/L)               | 3.5-7     |
| Protein, total (g/dL)           | 5.4-7.5   |
|                                 |           |

|                                 |                              |
|---------------------------------|------------------------------|
| Albumin (g/dL)                  | 2.5-5                        |
| Globulin (g/dL)                 | 1.5-3.5                      |
| Sodium (mEq/L)                  | 138-155                      |
| Triglycerides (mg/dL)           | 124-156                      |
| T <sub>3</sub> (ng/dL)          | 130-430                      |
| T <sub>4</sub> (μg/dL)          | 1.7-2.4                      |
| Urea nitrogen (mg/dL)           | 15-50                        |
| Vitamin A, plasma (μg/mL)       | 30-80                        |
| Vitamin E, plasma (μg/mL)       | >1                           |
| Vitamin D <sub>3</sub> (pmol/L) | 20-45 (free-range, outdoors) |

TABLE 9-8 Biologic and Physiologic Data of Rabbits.[61](#)

| Parameter                       | Normal Values              |
|---------------------------------|----------------------------|
| Adult body weight, male (buck)  | 1.5-5 kg                   |
| Adult body weight, female (doe) | 1.5-6 kg                   |
| Birth weight                    | 30-80 g                    |
| Respiratory rate                | 30-60 breaths/min          |
| Tidal volume                    | 4-6 mL/kg                  |
| Heart rate                      | 130-325 beats/min          |
| Rectal temperature              | 38.5-40°C (101.3-104°F)    |
| Life span                       | 5-6 years (up to 15 years) |
| Food consumption                | 50 g/kg/day                |
| Water consumption               | 100 mL/kg/day              |
| Gastrointestinal transit time   | 4-5 hours                  |
| Breeding onset, male            | 6-10 months                |
| Breeding onset, female          | 4-9 months                 |
| Breeding life of female         | 4 months to 3.75 years     |
| Reproductive cycle              | Induced ovulation          |
| Gestation period                | 29-35 days                 |
| Litter size                     | 4-10                       |
| Weaning age                     | 4-6 weeks                  |
| Dental formula                  | I2/1 C0/0 P3/2 M3/3        |

TABLE 9-9 Urinalysis Values in Rabbits.[144](#),[150](#)

| Measurement                          | Normal Values                                                                            |
|--------------------------------------|------------------------------------------------------------------------------------------|
| Urine volume                         |                                                                                          |
| Large breeds                         | 20-350 mL/kg/day                                                                         |
| Average breeds                       | 130 mL/kg/day                                                                            |
| Specific gravity                     | 1.003-1.051                                                                              |
| pH                                   | 7.7-9.6                                                                                  |
| Crystals                             | Ammonium magnesium phosphate, calcium carbonate monohydrate, anhydrous calcium carbonate |
| Casts, epithelial cells, or bacteria | Absent to rare                                                                           |
| Leukocytes or erythrocytes           | Occasional                                                                               |
| Albumin                              | Occasional in young rabbits                                                              |
| Protein:creatinine ratio             | 0.11-0.47                                                                                |
| Protein (g/L, reference assay)       | 0.57-10.66                                                                               |
| Protein (Multistix dipsticks)        | Negative to +++                                                                          |

TABLE 9-10 Cerebrospinal Fluid Values in Rabbits.[80,177](#)

| Measurement          | Normal values                                                      |
|----------------------|--------------------------------------------------------------------|
| Leukocyte count      | ≤4 cells/μL (1-97 cells/μL in <i>E. cuniculi</i> positive rabbits) |
| Alkaline phosphatase | 5 U/dL                                                             |
| Calcium              | 5.4 mEq/L                                                          |
| Carbon dioxide       | 41.2-48.5 mL%                                                      |
| Chloride             | 127 mEq/L                                                          |
| Cholesterol          | 33 mg/dL                                                           |
| Creatinine           | 17 mg/dL                                                           |
| Glucose              | 75 mg/dL                                                           |
| Lactic acid          | 1.4-4 mg/dL                                                        |
| Magnesium            | 2.2 mEq/L                                                          |
| Nitrogen, nonprotein | 5.6-16.8 mg/dL                                                     |
| Phosphate            | 2.3 mEq/L                                                          |
| Potassium            | 3 mEq/L                                                            |
|                      |                                                                    |



|                |                                                                   |
|----------------|-------------------------------------------------------------------|
| Protein, total | 13-59 mg/dL (31-154 mg/dL in <i>E. cuniculi</i> positive rabbits) |
| Sodium         | 149 mEq/L                                                         |
| Urea nitrogen  | 20 mg/dL                                                          |

TABLE 9-11 Electrocardiographic Values in Rabbits.[54,75](#)

| ECG Parameter          | Normal Values                  |
|------------------------|--------------------------------|
| Heart rate             | 198-330 beats/min <sup>a</sup> |
| Measurements (lead II) |                                |
| P wave                 |                                |
| Duration (width)       | 0.01-0.05 sec                  |
| Amplitude (height)     | 0.04-0.12 mv                   |
| P-R interval           |                                |
| Duration               | 0.04-0.08 sec                  |
| QRS complex            |                                |
| Duration               | 0.02-0.06 sec                  |
| R-wave amplitude       | 0.03-0.039 mv                  |
| Q-T interval           |                                |
| Duration               | 0.08-0.16 sec                  |
| T wave                 |                                |
| Amplitude              | 0.05-0.17 mv                   |

|                                                     |                    |
|-----------------------------------------------------|--------------------|
| Electrical axis (frontal plane)                     | -43 to +80 degrees |
| Thickness of interventricular septum in diastole    | 0.143-0.310 cm     |
| Thickness of interventricular septum in systole     | 0.217-0.403 cm     |
| Left ventricular internal diameter in diastole      | 1.187-1.906 cm     |
| Left ventricular internal diameter in systole       | 0.783-1.353 cm     |
| Thickness of left ventricular free wall in diastole | 0.16-0.28 cm       |
| Thickness of left ventricular free wall in systole  | 0.243-0.455 cm     |
| Fractional shortening                               | 22.6-36.83 %       |
| Ejection fraction                                   | 49.07-70 %         |
| Aortic diameter                                     | 0.673-0.980 cm     |
| Left atrial appendage diameter                      | 0.753-1.200 cm     |
| Left atrial appendage diameter:aortic diameter      | 0.94-1.54          |
| Mitral valve E-point-to-septal separation interval  | 0.120-0.233 cm     |
| Doppler heart rate                                  | 115-234 beats/min  |
| Maximal aortic outflow velocity                     | 0.56-1.06 m/sec    |
| Maximal pulmonary artery outflow velocity           | 0.34-0.84 m/sec    |
| Maximal mitral E-wave velocity                      | 0.41-0.83 m/sec    |
| Maximal mitral A-wave velocity                      | 0.19-0.44 m/sec    |
| Maximal mitral E-wave velocity:A-wave velocity      | 1.34-3.55          |

<sup>a</sup> Lower values may be expected in acclimated rabbits.

TABLE 9-12 Determining the Sex of Mature Rabbits.<sup>[157](#)</sup>

| Male                                                                                                                                                                         | Female                                                                                                                                                                                                                                                           |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <ul style="list-style-type: none"> <li>• Protrude penis by manipulating skin of prepuce</li> <li>• Palpate for testicles</li> <li>• Anogenital distance is longer</li> </ul> | <ul style="list-style-type: none"> <li>• There is a common orifice for both the vagina and urethra (like dogs and cats)</li> <li>• No structure like a “penis” can be protruded from the urogenital orifice</li> <li>• Anogenital distance is shorter</li> </ul> |

TABLE 9-13 Drugs Reported to be Toxic in Rabbits.<sup>[a](#)</sup>

| Drug                                      | Comments                 |
|-------------------------------------------|--------------------------|
| Amoxicillin <sup><a href="#">71</a></sup> | Enteritis; enterotoxemia |
|                                           |                          |

|                                           |                                                                |
|-------------------------------------------|----------------------------------------------------------------|
| Amoxicillin/clavulanic acid <sup>71</sup> | Enteritis; enterotoxemia                                       |
| Ampicillin <sup>27,60</sup>               | Enteritis; enterotoxemia, high risk especially if given orally |
| Cephalosporins <sup>60</sup>              | Enteritis; enterotoxemia if given orally                       |
| Clindamycin <sup>27,60</sup>              | Enteritis; enterotoxemia, high risk                            |
| Erythromycin <sup>27</sup>                | Enteritis; enterotoxemia                                       |
| Lincomycin <sup>27,60</sup>               | Enteritis; enterotoxemia, high risk                            |
| Penicillin <sup>27,60</sup>               | Enteritis; enterotoxemia if given orally                       |
| Procaine <sup>61</sup>                    | May be fatal at doses of 0.4 mg/kg                             |
| Tiletamine <sup>38</sup>                  | Nephrotoxic                                                    |

<sup>a</sup> There have also been some reports of antibiotic-related colitis in rabbits given penicillin/streptomycin, trimethoprim/sulfamethoxazole, tetracycline, and gentamicin. In general, parenteral antibiotic therapies are preferred over oral.

TABLE 9-14 Medical Treatment for Gastric Stasis/Ileus and Trichobezoars in Rabbits. [a,30,62,71,97,111,119,144,167](#)

| Treatment                | Comments                                                                                                                                                                                                                                          |
|--------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Analgesics               | <ul style="list-style-type: none"> <li>Use for abdominal discomfort, thereby stimulating appetite</li> </ul>                                                                                                                                      |
| Antibiotics              | <ul style="list-style-type: none"> <li>Use only when indicated; enrofloxacin or trimethoprim/sulfa are generally the drugs of choice; use parenterally until stools are passed; metronidazole may be indicated for anaerobe overgrowth</li> </ul> |
| Exercise                 | <ul style="list-style-type: none"> <li>Increasing activity may aid in passage of trichobezoars</li> </ul>                                                                                                                                         |
| Fluid therapy            | <ul style="list-style-type: none"> <li>Rehydration (via PO, SC, IV) at 2-3 × maintenance is essential</li> <li>Maintenance fluids is 50-100 mL/kg/day</li> </ul>                                                                                  |
| Oral (gastric) hydration | <ul style="list-style-type: none"> <li>Important to rehydrate any material in stomach</li> <li>Can use balanced electrolyte solutions</li> </ul>                                                                                                  |
| Grooming                 | <ul style="list-style-type: none"> <li>Brushing the hair may prevent an exacerbation of the problem</li> </ul>                                                                                                                                    |

|                                                   |                                                                                                                                                                                                                                                                                                                                                                                                                                   |
|---------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                                                   | <ul style="list-style-type: none"> <li>• Routinely brushing long-haired or heavy-shedding individuals for prevention</li> </ul>                                                                                                                                                                                                                                                                                                   |
| Nutritional support                               | <ul style="list-style-type: none"> <li>• Important in the anorectic rabbit; helps prevent hepatic lipidosis</li> <li>• Assist-feed &lt;10-15 mL/kg q8-12h Critical Care for Herbivores (Oxbow Pet Products)</li> <li>• Offer fresh greens (parsley, romaine lettuce, carrot tops, kale, cilantro, etc) and timothy or grass hay ad libitum; withhold pellets</li> <li>• Vitamin supplements (especially vitamin B) prn</li> </ul> |
| Motility modifiers                                | <ul style="list-style-type: none"> <li>• Promotes gastric emptying</li> <li>• Cisapride (0.5 mg/kg PO q8-12h)</li> <li>• Metoclopramide (0.2-0.5 mg/kg PO, SC q6-8h)</li> </ul>                                                                                                                                                                                                                                                   |
| Other treatments (see <a href="#">Table 9-6</a> ) | <ul style="list-style-type: none"> <li>• Cholestyramine: treating/preventing enterotoxemia</li> <li>• Simethicone: may reduce abdominal discomfort associated with excess gas</li> <li>• Sulfasalazine: may reduce inflammation of intestinal mucosa</li> </ul>                                                                                                                                                                   |
| Laxative, feline                                  | <ul style="list-style-type: none"> <li>• Because their effectiveness is equivocal, petroleum-based laxatives are probably not indicated</li> </ul>                                                                                                                                                                                                                                                                                |
| Enzyme supplements                                | <ul style="list-style-type: none"> <li>• Use of proteolytic enzymes such as bromelain (present in fresh pineapple juice) have been used empirically in cases of trichobezoars; however, their contribution to resolving the problem is equivocal, and they are generally not recommended</li> </ul>                                                                                                                               |

<sup>a</sup> Concurrent to treatment, it is important to correct the cause (e.g., boredom, stress, excessive shedding, inadequate dietary roughage, nutritional deficiency or imbalance, obesity). Surgical intervention is no longer considered the primary treatment option and is rarely indicated except in cases of complete obstruction.

TABLE 9-15 Bronchoalveolar Lavage (BAL) in Rabbits. [a,65](#)

| BAL Parameter | Results and Comments         |
|---------------|------------------------------|
| Volume        | 40-76% recovery = 1.2-2.3 mL |
|               |                              |

|                 |                                             |
|-----------------|---------------------------------------------|
| Leukocyte count | 200-700 cells/μL, predominantly macrophages |
| Heterophils     | 0-28 cells/μL (0-5%)                        |
| Lymphocytes     | 15-98 cells/μL (4-30%)                      |
| Macrophages     | 180-602 cells/μL (69-94%)                   |
| Eosinophils     | 0-60 cells/μL (0-12%)                       |

<sup>a</sup> Bronchoscopic bronchoalveolar lavage in New Zealand white rabbits was performed with 3 mL of sterile saline into both left bronchus and right bronchus.

TABLE 9-16 Normal Pet Rabbit Behavior.<sup>a</sup>

| Behavior        | Description                                               | %    |
|-----------------|-----------------------------------------------------------|------|
| Alert           | Alert but inactive                                        | 24.2 |
| Social          | Social interactions including social resting and grooming | 16.5 |
| Grooming        | Grooming on its own                                       | 16   |
| Resting         | Resting on its own                                        | 12.3 |
| Eating          | Eating other than grazing                                 | 8.4  |
| Hopping         | Hopping                                                   | 6.4  |
| Grazing         | Grazing grass                                             | 3.4  |
| Playing         | Playing with a toy                                        | 2.8  |
| Drinking        | Drinking                                                  | 2    |
| Other behaviors | Scent marking                                             | 0.9  |
|                 | Running/fast hopping                                      | 0.7  |
|                 | Standing on hindlegs                                      | 0.7  |
|                 | Thumping                                                  | 0.5  |
|                 | Defecating/urinating                                      | 0.5  |
|                 | Digging                                                   | 0.5  |
|                 | Stretching/shaking                                        | 0.1  |
| Not visible     | Not visible to observer                                   | 4    |

<sup>a</sup> Percentages of the assessments made every 30 seconds during a 10-minute observation period of 97 rabbits which were performing a variety of behaviors.<sup>121</sup>

TABLE 9-17 Conjunctival Flora from 70 Healthy Rabbits.<sup>36</sup>

| Bacteria                                                               | % of Eyes Sampled |
|------------------------------------------------------------------------|-------------------|
| <i>Staphylococcus</i> spp, esp <i>S. capitis</i> and <i>S. xylosus</i> | 56                |
|                                                                        |                   |

|                                    |    |
|------------------------------------|----|
| <i>Micrococcus</i> spp             | 25 |
| <i>Bacillus</i> spp                | 19 |
| <i>Stomotococcus mucilaginosus</i> | 8  |
| <i>Neisseria</i> spp               | 8  |
| <i>Corynebacterium</i> spp         | 6  |
| <i>Streptococcus viridans</i>      | 6  |
| <i>Pasteurella</i> spp             | 6  |
| <i>Moraxella</i> spp               | 4  |
| <i>Weeksella</i> spp               | 3  |
| <i>Aeromonas salmonicida</i>       | 2  |
| <i>Flavobacterium indologenes</i>  | 1  |
| <i>Lactobacillus</i> spp           | 1  |

### References

1. Abd El-Aty AM, Goudah A, Abo El-Sooud K. Pharmacokinetics, intramuscular bioavailability and tissue residue profiles of ceftazidime in a rabbit model. *Dtsch Tierarztl Wochenschr.* 2001;108:168–171.
2. Abd El-Aty AM, Goudah A, Abo El-Sooud K, et al. Pharmacokinetics and bioavailability of florfenicol following intravenous, intramuscular, and oral administration in rabbits. *Vet Res Commun.* 2004;28:515–524.
3. Abd El-Aty AM, Goudah A, Ismail M, et al. Disposition kinetics of difloxacin in rabbits after intravenous and intramuscular injection of Dicural. *Vet Res Commun.* 2005;29:297–304.
4. Abo-El-Sooud K, Goudah A. Influence of *Pasteurella multocida* infection on the pharmacokinetic behavior of marbofloxacin after intravenous and intramuscular administrations in rabbits. *J Vet Pharmacol Ther.* 2009;33:63–68.
5. Akpek EK, Vittitow J, Verhoeven RS, et al. Ocular surface distribution and pharmacokinetics of a novel ophthalmic 1% azithromycin formulation. *J Ocul Pharmacol Ther.* 2009;25:433–440.
6. Allen DG, Pringle JK, Smith DA. *Handbook of Veterinary Drugs*. Philadelphia: JB Lippincott Co; 1993.

7. Allweiler S, Leach MC, Flecknell PA. The use of propofol and sevoflurane for surgical anaesthesia in New Zealand white rabbits. *Lab Anim*. 2010;44:113–117.
8. Audeval-Gerard C, Nivet C, el Amrani A, et al. Pharmacokinetics of ketoprofen in rabbits after single topical application. *Eur J Drug Metab Pharmacokinet*. 2000;25:227–230.
9. Avunduk AM, Beuerman RW, Warnel ED, et al. Comparison of efficacy of topical and oral fluconazole treatment in experimental *Aspergillus* keratitis. *Curr Eye Res*. 2003;26:113–117.
10. Barequet IS, Denton P, Osterhout GJ, et al. Treatment of experimental bacterial keratitis with topical trovafloxacin. *Arch Ophthalmol*. 2004;122:65–69.
11. Benedetti M, Coupez R, Whomsley R, et al. Comparative pharmacokinetics and metabolism of levetiracetam, a new anti-epileptic agent, in mouse, rat, rabbit, and dog. *Xenobiotic*. 2004;34:281–300.
12. Bennett RA. Rabbit and rodent orthopedics. *Proc North Am Vet Conf*; 1998:773–774.
13. Bennett RA. Soft tissue surgery in rabbits. *Proc North Am Vet Conf*; 1998:775–776.
14. Bennett RA. Treatment of abscesses in the head of rabbits. *Proc North Am Vet Conf*; 1999:821–823.
15. Birke L, Molina P, Baker D, et al. Comparison of selamectin and imidacloprid plus permethrin in eliminating *Leporacarus gibbus* infestation in laboratory rabbits. *J Am Assoc Lab Anim Sci*. 2009;48:757–762.
16. Blair MJ, Render JA, Morreale R, et al. Granulocyte macrophage colony stimulating factor. effect on corneal wound healing. *Vet Comp Ophthalmol*. 1997;7:168–172.
17. Bowman DD, Fogelson ML, Carbone LG. Effect of ivermectin on the control of ear mites (*Psoroptes cuniculi*) in naturally infested rabbits. *Am J Vet Res*. 1992;53:105–109.

18. Broome RL, Brooks DL. Efficacy of enrofloxacin in the treatment of respiratory pasteurellosis in rabbits. *Lab Anim Sci*. 1991;41:572–576.
19. Broome RL, Brooks DL, Babish JG, et al. Pharmacokinetic properties of enrofloxacin in rabbits. *Am J Vet Res*. 1991;52:1835–1841.
20. Brown SA. Intermittent soft stools in rabbits. *Proc North Am Vet Conf*. 1996:849–850.
21. Brown SA. Rabbit urinary tract disease. *Proc North Am Vet Conf*; 1997:785–787.
22. Burgmann P, Percey DH. Antimicrobial drug use in rodents and rabbits. In: Prescott JF, Baggot JD. *Antimicrobial Therapy in Veterinary Medicine*. Ames: Iowa State University Press; 1993:524–541.
23. Cabanes A, Arboix M, Anton JMG, et al. Pharmacokinetics of enrofloxacin after intravenous and intramuscular injection in rabbits. *Am J Vet Res*. 1992;53:2090–2093.
24. Cam Y, Atasever A, Eraslan G, et al. Experimental infection in rabbits and the effect of treatment with toltrazuril and ivermectin. *Exper Parasitol*. 2008;119:164–172.
25. Cantwell S. Ferret, rabbit, and rodent anesthesia. *Vet Clin North Am Exotic Anim Pract*. 2001;4:169–191.
26. Carceles CM, Fernandez-Varon E, Marin P, et al. Tissue disposition of azithromycin after intravenous and intramuscular administration to rabbits. *Vet J*. 2007;174:154–159.
27. Carman RJ. Antibiotic-associated diarrhea of rabbits. *J Small Exotic Anim Med*. 1993;2:69–71.
28. Carpenter JW. *MG Hawkins*. Personal communication; 2011.
29. Carpenter JW, Dryden M, KuKanich B. *Efficacy and pharmacokinetics of topical administration of selamectin in flea-infested rabbits*. *Am J Vet Res*; 2012.



30. Carpenter JW, Mashima TY, Gentz EJ, et al. Caring for rabbits. an overview and formulary. *Vet Med*. 1995;April:340–364.
31. Carpenter JW, Pollock CG, Koch DE, et al. Single- and multiple-dose pharmacokinetics of marbofloxacin after oral administration to rabbits. *Am J Vet Res*. 2009;70:522–526.
32. Carpenter JW, Pollock CG, Koch DE, et al. Single- and multiple-dose pharmacokinetics of meloxicam after oral administration to the rabbit (*Oryctolagus cuniculus*). *J Zoo Wildl Med*. 2009;40:601–606.
33. Cocksholt ID, Douglas EJ, Plummer GF, et al. The pharmacokinetics of propofol in laboratory animals. *Xenobiotica*. 1992;22:369–375.
34. Collins BR. Antimicrobial drug use in rabbits, rodents, and other small mammals. In: *Antimicrobial Therapy in Caged Birds and Exotic Pets*. Trenton: Veterinary Learning Systems Co; 1995:3–10.
35. Cooper CS, Metcalf-Pate KA, Barat CE, et al. Comparison of side effects between buprenorphine and meloxicam used postoperatively in Dutch belted rabbits (*Oryctolagus cuniculus*). *J Am Assoc Lab Anim Sci*. 2009;48:279–285.
36. Cooper S, McLellan G, Rycroft A. Conjunctival flora observed in 70 healthy domestic rabbits (*Oryctolagus cuniculus*). *Vet Rec*. 2001;149:232–235.
37. Deren YT, Ozdek S, Kalkanci A, et al. Comparison of antifungal efficacies of moxifloxacin, liposomal amphotericin B, and combination treatment in experimental *Candida albicans* endophthalmitis in rabbits. *Can J Microbiol*. 2010;56:1–7.
38. Doerning BJ, Brammer DW, Chrisp CE, et al. Nephrotoxicity of tiletamine in New Zealand white rabbits. *Lab Anim Sci*. 1992;42:267–269.
39. Drago F, Emmi I, Marino V. Effects of beta-blockers association with pilocarpine on rabbit intraocular pressure and heart rate. *Pharm Res*. 1997;35:299–302.

40. Drummond JC. MAC for halothane, enflurane, and isoflurane in the New Zealand white rabbit. and a test for the validity of MAC determinations. *Anesthesiology*. 1985;62:336–338.
41. Dundaroz R, DeGim T, Sizlan A, et al. Intracavernous application of diazepam. an alternative route of the seizure treatment—an experimental study in rabbits. *Pediatr Int*. 2002;44:163–167.
42. Egger CM, Souza MJ, Greenacre CB, et al. Effect of intravenous administration of tramadol hydrochloride on the minimum alveolar concentration of isoflurane in rabbits. *Am J Vet Res*. 2009;70:945–949.
43. Eisle PH. Anesthesia for the rabbit. *Proc North Am Vet Conf*; 1997:792–794.
44. Elmas M, Uney K, Yazar E, et al. Pharmacokinetics of enrofloxacin following intravenous and intramuscular administration in Angora rabbits. *Res Vet Sci*. 2007;82:242–245.
45. Fairham J, Harcourt-Brown F. Preliminary investigation of the vitamin D status of pet rabbits. *Vet Rec*. 1999;145:452–454.
46. Farmaki R, Koutinas AF, Papazahariadou MG, et al. Effectiveness of a selamectin spot-on formulation in rabbits with sarcoptic mange. *Vet Rec*. 2009;164:431–432.
47. Fernandez-Varon E, Bovaira MJ, Espuny A, et al. Pharmacokinetic-pharmacodynamic integration of moxifloxacin in rabbits after intravenous, intramuscular and oral administration. *J Vet Pharmacol Ther*. 2005;28:343–348.
48. Fiorello CV. Personal observation; 2011.
49. Fish RE, Besch-Williford C. Reproductive disorders in the rabbit and guinea pig. In: Kirk RW, Bonagura JD. *Kirk's Current Veterinary Therapy XI: Small Animal Practice*. Philadelphia: WB Saunders Co; 1992:1175–1179.
50. Flecknell P. Medetomidine and atipamezole. potential uses in laboratory animals. *Lab Anim*. 1997;26:21–25.

51. Flecknell PA. *Laboratory Animal Anesthesia*. London: Academic Press; 1987.
52. Flecknell PA. Post-operative analgesia in rabbits and rodents. *Lab Anim*. 1991;20:34–37.
53. Foley P, Henderson A, Bissonette E, et al. Evaluation of fentanyl transdermal patches in rabbits. blood concentrations and physiologic response. *Comp Med*. 2001;51:239–244.
54. Fontes-Sousa AP, Brás-Silva C, Moura C, et al. M-mode and Doppler echocardiographic reference values for male New Zealand white rabbits. *Am J Vet Res*. 2006;67:1725–1729.
55. Gallina G, Lucatello L, Drigo I, et al. Kinetics and intrapulmonary disposition of tilmicosin after single and repeated oral bolus administrations to rabbits. *Vet Res Commun*. 2010;34:S69–S72.
56. Gillett CS. Selected drug dosages and clinical reference data. In: Manning PJ, Ringler DH, Newcomer CE. *The Biology of the Laboratory Rabbit*. 2nd ed. San Diego: Academic Press; 1994:467–472.
57. Gokbulut C, Biligili A, Kart A, et al. Plasma dispositions of ivermectin, doramectin and moxidectin following subcutaneous administration in rabbits. *Lab Anim*. 2010;44:138–142.
58. Green LC, Callegan MC, Engel LS, et al. Pharmacokinetics of topically applied ciprofloxacin in rabbit tears. *Jpn J Ophthalmol*. 1996;40:123–126.
59. Grint NJ, Murison PJ. A comparison of ketamine-midazolam and ketamine-medetomidine combinations for induction of anaesthesia in rabbits. *Vet Anaesth Analg*. 2008;35:113–121.
60. Harcourt-Brown F. *Textbook of Rabbit Medicine*. Oxford: Butterworth-Heinemann; 2002.
61. Harkness JE, Wagner JE. *The Biology and Medicine of Rabbits and Rodents*, 3rd ed. Philadelphia: Lea and Febiger; 1989.

62. Harkness JE, Wagner JE. *The Biology and Medicine of Rabbits and Rodents*, 4th ed. Philadelphia: Williams & Wilkins; 1995.
63. Harrenstien L. Critical care of ferrets, rabbits, and rodents. *Semin Avian Exotic Pet Med*. 1994;3:217–228.
64. Harvey C. Rabbit and rodent skin diseases. *Semin Avian Exotic Pet Med*. 1995;4:195–204.
65. Hawkins MG, Vernau W, Drazenovich TL, et al. Results of cytologic and microbiologic analysis of bronchoalveolar lavage fluid in New Zealand white rabbits. *Am J Vet Res*. 2008;69:572–578.
66. Heard DJ. Principles and techniques of anesthesia and analgesia for exotic practice. *Vet Clin North Am Small Anim Pract*. 1993;23:1301–1327.
67. Heard DJ. Anesthesia, analgesia, and sedation of small mammals. In: Quesenberry KE, Carpenter JW. *Ferrets, Rabbits, and Rodents: Clinical Medicine and Surgery*. 2nd ed. St Louis: WB Saunders Co; 2004:356–369.
68. Hellebrekers LJ, de Boer EJW, van Zuylen MA, et al. A comparison between medetomidine-ketamine and medetomidine-propofol anaesthesia in rabbits. *Lab Anim*. 1997;31:58–69.
69. Henke J, Astner S, Brill T, et al. Comparative study of three intramuscular anaesthetic combinations (medetomidine-ketamine, medetomidine-fentanyl-midazolam and xylazine-ketamine) in rabbits. *Vet Anaesth Analg*. 2005;32:261–270.
70. Hersey-Benner C. Diarrhea in a rabbit. *Lab Anim*. 2008;37:347–349.
71. Hillyer EV. Pet rabbits. *Vet Clin North Am Small Anim Pract*. 1994;24:25–64.
72. Hiraoka T, Kaji Y, Wakabayashi T, et al. Comparison of micafungin and fluconazole for experimental *Candida* keratitis in rabbits. *Cornea*. 2007;26:336–342.
73. Hu L, Liu C, Shang C, et al. Pharmacokinetics and improved bioavailability of

toltrazuril after oral administration to rabbits. *J Vet Pharmacol Ther.* 2010;33:503–506.

74. Huerkamp MJ. Anesthesia and postoperative management of rabbits and pocket pets. In: Bonagura JD, ed. *Kirk's Current Veterinary Therapy XII: Small Animal Practice*. Philadelphia: WB Saunders Co; 1995:1322–1327.

75. Huston SM, Quesenberry KE. Cardiovascular and lymphoproliferative diseases. In: Quesenberry KE, Carpenter JW. *Ferrets, Rabbits, and Rodents: Clinical Medicine and Surgery*. 2nd ed. St Louis: WB Saunders Co; 2004:211–220.

76. Hutchinson MJ, Jacobs DE, Bell GD, et al. Evaluation of imidacloprid for the treatment and prevention of cat flea (*Ctenocephalides felis felis*) infestations on rabbits. *Vet Rec.* 2001;148:695–696.

77. Idid S, Lee C. Effects of Fuller's Earth and activated charcoal on oral absorption of paraquat in rabbits. *Clin Exp Pharmacol Physiol.* 1996;23:679–681.

78. Ivey E. Personal communication; 2002.

79. Ivey ES, Morrissey JK. Therapeutics for rabbits. *Vet Clin North Am Exotic Anim Pract.* 2000;3:183–220.

80. Jass A, Matiasek K, Henke J, et al. Analysis of cerebrospinal fluid in healthy rabbits and rabbits with clinically suspected encephalitozoonosis. *Vet Rec.* 2008;162:618–622.

81. Jenkins J. Rabbits. In: Jenkins JR, Brown SA. *A Practitioner's Guide to Rabbits and Ferrets*. Lakewood, CO: American Animal Hospital Association; 1993:1–42.

82. Jenkins J. *Rabbit Drug Doses*. Lakewood, CO: American Animal Hospital Association; 1995.

83. Jepson L. *Exotic Animal Medicine. A Quick Reference Guide*. Philadelphia: Saunders/Elsevier; 2009.

84. Kanbur M, Atalay O, Ica A, et al. The curative and antioxidative efficiency of doramectin and doramectin+vitamin AD<sub>3</sub>E treatment on *Psoroptes cuniculi* infestation in rabbits. *Res Vet Sci*. 2008;85:291–293.
85. Kaya D, Inceboz T, Kolatan E, et al. Comparison of efficacy of ivermectin and doramectin against mange mite (*Sarcoptes scabiei*) in naturally infested rabbits in Turkey. *Vet Ital*. 2010;46:51–56.
86. Kern TJ. Rabbit and rodent ophthalmology. *Semin Avian Exotic Pet Med*. 1997;6:138–145.
87. Kiel JW, Patel P. Effects of timolol and betaxolol on choroidal blood flow in the rabbit. *Exp Eye Res*. 1998;67:501–507.
88. Kim MS, Lim JH, Hwang YH, et al. Plasma disposition of toltrazuril and its metabolites, toltrazuril sulfoxide and toltrazuril sulfone, in rabbits after oral administration. *Vet Parasitol*. 2010;169:51–56.
89. Kim SH, Lee JY, Jun HK, et al. Efficacy of selamectin in the treatment of cheyletiellosis in pet rabbits. *Vet Dermatol*. 2008;19:26–27.
90. Kirkpatrick WR, Vallor AC, McAtee RK, et al. Combination therapy with terbinafine and amphotericin B in a rabbit model of experimental invasive aspergillosis. *Antimicrob Agents Chemother*. 2005;49:4751–4753.
91. Kirschner SE. Ophthalmologic diseases in small mammals. In: Hillyer EV, Quesenberry KE. *Ferrets, Rabbits, and Rodents: Clinical Medicine and Surgery*. Philadelphia: WB Saunders Co; 1997:339–345.
92. Koc F, Ozturk M, Kadioglu Y, et al. Pharmacokinetics of florfenicol after intravenous and intramuscular administration in New Zealand white rabbits. *Res Vet Sci*. 2009;87:102–105.
93. Korting HC, Walther D, Riethmüller U, et al. Ceftriaxone given repeatedly cures manifest syphilis in the rabbit. *Chemother*. 1987;33:376–380.
94. Kosravi E, Elena P, Hariton C. Allergic conjunctivitis and uveitis models. reappraisal with some marketed drugs. *Inflamm Res*. 1995;44:47–54.

95. Kozer E, Levichek Z, Hoshino N, et al. The effect of amitriptyline, gabapentin, and carbamazepine on morphine-induced hypercarbia in rabbits. *Anesth Analg*. 2008;107:1216–1222.
96. Kraus AL, Wesbroth SH, Flatt RE. Biology and diseases of rabbits. In: Fox JG, Cohen BJ, Loew FM, et al. *Laboratory Animal Medicine*. Orlando: Academic Press; 2000:207–240.
97. Krempels D, Cotter M, Stanzione G. Ileus in domestic rabbits. *Exotic DVM*. 2000;2:19–21.
98. Kurtkede A, Karaer Z, Acar A, et al. Use of selamectin for the treatment of psoroptic and sarcoptic mite infestation in rabbits. *Vet Dermatol*. 2007;18:18–22.
99. Lee M, Kallal S, Feldman M. Omeprazole prevents indomethacin-induced gastric ulcers in rabbits. *Aliment Pharmacol Ther*. 1996;10:571–576.
100. Lipman NS, Marini RP, Erdman SE. A comparison of ketamine/xylazine and ketamine/xylazine/acepromazine anesthesia in the rabbit. *Lab Anim Sci*. 1990;40:395–398.
101. Lipman NS, Marini RP, Flecknell PA. Anesthesia and analgesia in rabbits. In: Kohn DF, Wixson SK, White WJ, et al. *Anesthesia and Analgesia in Laboratory Animals*. New York: Academic Press; 1997:205–232.
102. Longley L. *Anaesthesia of Exotic Pets*. Philadelphia: Saunders/Elsevier; 2008.
103. Louie A, Liu QF, Drusano GL, et al. Pharmacokinetic studies of fluconazole in rabbits characterizing doses which achieve peak levels in serum and area under the concentration-time curve values which mimic those of high-dose fluconazole in humans. *Antimicrob Agents Chemother*. 1998;42:1512–1514.
104. Lukehart SA, Fohn MJ, Baker-Zander SA. Efficacy of azithromycin for therapy of active syphilis in the rabbit model. *J Antimicrob Chemother*. 1990;25:91–99.
105. Maciejewska-Paszek I, Pawlowska-Góral K, Kostrzewski M, et al. The

- influence of small doses of paracetamol on rabbit liver. *Exp Toxicol Pathol*. 2007;59:139–141.
106. Marangos MN, Zhu Z, Nicolau DP, et al. Disposition of ofloxacin in female New Zealand white rabbits. *J Vet Pharmacol Ther*. 1997;20:17–20.
107. Marini RP, Avison DL, Corning BF, et al. Ketamine-xylazine-butorphanol. a new anesthetic combination for rabbits. *Lab Anim Sci*. 1992;42:57–62.
108. McElroy DE, Ravis WR, Clark CH. Pharmacokinetics of oxytetracycline hydrochloride in rabbits. *Am J Vet Res*. 1987;48:1261–1263.
109. McGee DH, Holt WF, Kastner PR, et al. Safety of moxifloxacin as shown in animal and in vitro studies. *Surv Ophthalmol*. 2005;50(Suppl 1):S46–54.
110. McKay SG, Morck DW, Merrill JK, et al. Use of tilmicosin for treatment of pasteurellosis in rabbits. *Am J Vet Res*. 1996;57:1180–1184.
111. McNitt JI, Cheeke PR. *Rabbit Production*. Danville, IL: Interstate Printers & Publishers; 1996.
112. McTier TL, Hair JA, Walstrom DJ, et al. Efficacy and safety of topical administration of selamectin for treatment of ear mite infestation in rabbits. *J Am Vet Med Assoc*. 2003;223:322–324.
113. Mencke N, Bach T. Managing gastrointestinal helminths in small mammals. *Comp Cont Educ Pract*. 2007;29:13–16.
114. Mercier P, Morel-Saives A, Verdelhan S, et al. Tolerance of decoquinate in the rabbit. Proc 8th World Rabbit Congr; 2004:597–600.
115. Miller JL, Schell WA, Wills EA, et al. In vitro and in vivo efficacies of the new triazole albaconazole against *Cryptococcus neoformans*. *Antimicrob Agents Chemother*. 2004;48:384–387.
116. Millis DL, Walshaw R. Elective castrations and ovariohysterectomies in pet rabbits. *J Am Anim Hosp Assoc*. 1992;28:491–498.



117. More RC, Kody MH, Kabo JM, et al. The effects of two nonsteroidal antiinflammatory drugs on limb swelling, joint stiffness, and bone torsional strength following fracture in a rabbit model. *Clin Orthop Relat Res*; 1989; Oct:306–311.
118. Morrisey JK. Ectoparasites of small mammals. *Proc North Am Vet Conf*; 1998:844–845.
119. Morrisey JK. Personal communication; 2004.
120. Morrisey JK, Carpenter JW. Formulary. In: Quesenberry KE, Carpenter JW. *Ferrets, Rabbits, and Rodents: Clinical Medicine and Surgery*. 3rd ed. St Louis: Saunders/Elsevier; 2012:566–575.
121. Mullan S, Main D. Behaviour and personality of pet rabbits and their interactions with their owners. *Vet Rec*. 2007;160:516–520.
122. Murphy KL, Roughan JV, Baxter MG, et al. Anaesthesia with a combination of ketamine and medetomidine in the rabbit. effect of premedication with buprenorphine. *Vet Anaesth Analg*. 2010;37:222–229.
123. Nelson CL, McLaren SG, Skinner RA, et al. The treatment of experimental osteomyelitis by surgical debridement and the implantation of calcium sulfate tobramycin pellets. *J Orthop Res*. 2002;20:643–647.
124. Ng EW, Joo MJ, Au Eong KG, et al. Ocular toxicity of intravitreal trovafloxacin in the pigmented rabbit. *Curr Eye Res*. 2003;27:387–393.
125. Nicolau DP, Freeman CD, Nightingale CH, et al. Pharmacokinetics of minocycline and vancomycin in rabbits. *Lab Anim Sci*. 1993;43:222–225.
126. Nielson VG, Sidhartha T, Brix AE, et al. Hextend® (hetastarch solution) decreases multiple organ injury and xanthine oxidase release after hepatoenteric ischemia-reperfusion in rabbits. *Crit Care Med*. 1997;25:1565–1574.
127. Norcross EW, Sanders ME, Moore Q, et al. Comparative efficacy of besifloxacin and other fluoroquinolones in a prophylaxis model of penicillin-resistant *Streptococcus pneumoniae* rabbit endophthalmitis. *J Ocul Pharmacol*

*Ther.* 2010;26:237–243.

128. Ofoefule SI, Onuoha LC, Okonta MJ, et al. Effect of activated charcoal on isoniazid absorption in rabbits. *Boll Chim Farm.* 2001;140:183–186.

129. Okerman L. *Diseases of Domestic Rabbits*, 2nd ed. Oxford: Blackwell Scientific Publications; 1994.

130. Okerman L, Devriese LA, Gevaert D, et al. In vivo activity of orally administered antibiotics and chemotherapeutics against acute septicaemic pasteurellosis in rabbits. *Lab Anim.* 1990;24:341–344.

131. Ollivier F, Delverdier M, Regnier A. Tolerance of the rabbit cornea to an n-butyl-ester cyanoacrylate adhesive (Vetbond®). *Vet Ophthalmol.* 2001;4:261–266.

132. Orr HE, Roughan JV, Flecknell PA. Assessment of ketamine and medetomidine anaesthesia in the domestic rabbit. *Vet Anaesth Analg.* 2005;32:271–279.

133. Ostergaard C, Sorensen TK, Knudsen JD, et al. Evaluation of moxifloxacin, a new 8-methoxyquinolone, for treatment of meningitis caused by a penicillin-resistant pneumococcus in rabbits. *Antimicrob Agents Chemother.* 1998;42:1706–1712.

134. Ozturk F, Kurt E, Inan UU, et al. The effects of prolonged acute use and inflammation on the ocular penetration of topical ciprofloxacin. *Int J Pharm.* 2000;204:97–100.

135. Pan B, Wang M, Xu F, et al. Efficacy of an injectable formulation of eprinomectin against *Psoroptes cuniculi*, the ear mange mite in rabbits. *Vet Parasitol.* 2006;137:386–390.

136. Pan BL, Zhang YF, Suo X, et al. Effect of subcutaneously administered diclazuril on the output of *Eimeria* species oocysts by experimentally infected rabbits. *Vet Rec.* 2008;162:153–155.

137. Patterson TF, Fothergill AW, Rinaldi MG. Efficacy of itraconazole solution

in a rabbit model of invasive aspergillosis. *Antimicrob Agents Chemother*. 1993;37:2307–2310.

138. Paul-Murphy J, Ramer JC. Urgent care of the pet rabbit. *Vet Clin North Am Exotic Anim Pract*. 1998;1:127–152.

139. Percy DH, Black WD. Pharmacokinetics of tetracycline in the domestic rabbit following intravenous or oral administration. *Can J Vet Res*. 1988;52:5–11.

140. Petraitis V, Petraitiene R, Groll AH, et al. Comparative antifungal activities and plasma pharmacokinetics of micafungin (FK463) against disseminated candidiasis and invasive pulmonary aspergillosis in persistently neutropenic rabbits. *Antimicrob Agents Chemother*. 2002;46:1857–1869.

141. Pichardo C, Docobo-Pérez F, Pachón-Ibáñez ME, et al. Efficacy of beta-lactams against experimental pneumococcal endocarditis caused by strains with different susceptibilities to penicillin. *J Antimicrob Chemother*. 2005;56:732–737.

142. Plumb D. *Plumb's Veterinary Drug Handbook*, 5th ed. Ames: Blackwell Publishing; 2005.

143. Proksch JW, Ward KW. Ocular pharmacokinetics/pharmacodynamics of besifloxacin, moxifloxacin, and gatifloxacin following topical administration to pigmented rabbits. *J Ocul Pharmacol Ther*. 2010;26:449–458.

144. Quesenberry KE. Rabbits. In: Birchard SJ, Sherding RG. *Saunders Manual of Small Animal Practice*. Philadelphia: WB Saunders Co; 1994:1345–1362.

145. Quesenberry KE. Personal communication; 2002.

146. Quimby JM, Gustafson DL, Samber BJ, et al. *Studies on the pharmacokinetics and pharmacodynamics of mirtazapine in healthy young cats*. J Vet Pharmacol Ther; 2010. epub

147. Ramer JC, Paul-Murphy J, Benson KG. Evaluating and stabilizing critically ill rabbits—Part I. *Comp Cont Educ Pract*. 1999;21:30–33.

148. Ramer JC, Paul-Murphy J, Benson KG. Evaluating and stabilizing critically

ill rabbits—Part II. *Comp Cont Educ Pract*. 1999;21:36–40.

149. Redrobe S, Gakos G, Elliot SC, et al. Comparison of toltrazuril and sulphadimethoxine in the treatment of intestinal coccidiosis in pet rabbits. *Vet Rec*. 2010;167:287–290.

150. Reusch B, Murray J, Papsouliotis K, et al. Urinary protein:creatinine ratio in rabbits in relation to their serological status to *Encephalitozoon cuniculi*. *Vet Rec*. 2009;164:293–295.

151. Rosenthal K. Epidural anesthesia. *Proc North Am Vet Conf*; 1996:876.

152. Rougier S, Galland D, Boucher S, et al. Epidemiology and susceptibility of pathogenic bacteria responsible for upper respiratory tract infections in pet rabbits. *Vet Microbiol*. 2006;115:192–198.

153. Saito K, Hasegawa A. Chloramphenicol treatment for rabbit syphilis. *J Vet Med Sci*. 2004;66:1301–1304.

154. Samudre S, Lattanzio F, Lossen V, et al. *Lacritin, a novel human tear glycoprotein, promotes sustained basal tearing and is well-tolerated*. *Invest Ophthalmol Vis Sci*; 2010. epub 10.1167/ivos.10-6220

155. Sanati H, Ramos C, Bayer A, et al. Combination therapy with amphotericin B and fluconazole against invasive candidiasis in neutropenic-mouse and infective-endocarditis rabbit models. *Antimicrob Agents Chemother*. 1997;41:1345–1348.

156. Scheller MS, Daidman LJ, Partridge BL. MAC of sevoflurane in humans and the New Zealand white rabbit. *Can J Anesth*. 1988;35:153–156.

157. Schuchman SM. Individual care and treatment of rabbits, mice, guinea pigs, hamsters, and gerbils. In: Kirk RW, ed. *Current Veterinary Therapy X: Small Animal Practice*. Philadelphia: WB Saunders Co; 1989:738–765.

158. Sharpnack DD, Mastin JP, Childress CP, et al. Quinolone arthropathy in juvenile New Zealand white rabbits. *Lab Anim Sci*. 1994;44:436–442.

159. Shirtliff M, Mader J, Calhoun J. Oral rifampin plus azithromycin or

clarithromycin to treat osteomyelitis in rabbits. *Clin Orthop*. 1999;359:229–236.

160. Smith DA, Burgmann PM. Formulary. In: Hillyer EV, Quesenberry KE. *Ferrets, Rabbits, and Rodents: Clinical Medicine and Surgery*. Philadelphia: WB Saunders Co; 1997:392–403.

161. Sorensen KN, Sobel RA, Clemons KV, et al. Comparative efficacies of terbinafine and fluconazole in treatment of experimental coccidioid meningitis in a rabbit model. *Antimicrob Agents Chemother*. 2000;44:3087–3091.

162. Souza MJ, Greenacre CB, Cox SK. Pharmacokinetics of orally administered tramadol in domestic rabbits (*Oryctolagus cuniculus*). *Am J Vet Res*. 2008;69:979–982.

163. Steinleitner A, Lambert H, Kazensky C, et al. Reduction of primary postoperative adhesion formation under calcium channel blockade in the rabbit. *J Surg Res*. 1990;48:42–45.

164. Stiles J, Didier E, Ritchie B, et al. Encephalitozoon cuniculi in the lens of a rabbit with phacoclastic uveitis. confirmation and treatment. *Vet Comp Ophthalmol*. 1997;7:233–238.

165. Suter C, Muller-Doblies UU, Hatt JM, et al. Prevention and treatment of Encephalitozoon cuniculi infection in rabbits with fenbendazole. *Vet Rec*. 2001;148:478–480.

166. Swartout MS, Gerken DF. Lead-induced toxicosis in two domestic rabbits. *J Am Vet Med Assoc*. 1987;191:717–719.

167. Taylor KH. Orphan rabbits. In: Gage LJ, ed. *Hand-rearing Wild and Domestic Mammals*. Ames: Iowa State Press; 2002:5–12.

168. Thomas P, Samant D, Zhu Z, et al. Long-term topical cyclosporine treatment improves tear production and reduces keratoconjunctivitis in rabbits with induced autoimmune dacryoadenitis. *J Ocul Pharmacol Ther*. 2009;25:285–291.

169. Toshida H, Nakayasu K, Kanai A. Effect of cyclosporine A eyedrops on tear secretion in the rabbit. *Jpn J Ophthalmol*. 1998;42:168–173.

170. Turner P, Chen H, Taylor W. Pharmacokinetics of meloxicam in rabbits after single and repeat oral dosing. *Comp Med*. 2006;56:63–67.
171. Uebelhart D, Thonar EJ, Zhang JW, et al. Protective effect of exogenous chondroitin 4, 6-sulfate in the acute degradation of articular cartilage in the rabbit. *Osteoarthr Cartilage*. 1998;6(Suppl A):6–13.
172. Ueng SW, Yuan LJ, Lee N, et al. In vivo study of hot compressing molded 50:50 poly (DL-lactide-co-glycolide) antibiotic beads in rabbits. *J Orthop Res*. 2002;20:654–661.
173. Vanparijs O, Desplenter L, Marsboom R. Efficacy of diclazuril in the control of intestinal coccidiosis in rabbits. *Vet Parasitol*. 1989;34:185–190.
174. Wagner R, Wendlberger U. Field efficacy of moxidectin in dogs and rabbits naturally infested with *Sarcoptes* spp., *Demodex* spp., and *Psoroptes* spp. mites. *Vet Parasitol*. 2000;93:149–158.
175. Walsh TJ, Petraitis V, Petraitiene R, et al. Experimental pulmonary aspergillosis due to *Aspergillus terreus*. pathogenesis and treatment of an emerging fungal pathogen resistant to amphotericin B. *J Infect Dis*. 2003;188:305–319.
176. Waterbury L, Flach A. Comparison of ketorolac tromethamine, diclofenac sodium, and loteprednol etabonate in an animal model of ocular inflammation. *J Ocul Pharmacol Ther*. 2006;22:155–159.
177. Weisbroth SH, Flatt RE, Kraus AL. *The Biology of the Laboratory Rabbit*. New York: Academic Press; 1975.
178. Welch WD, Lu YS, Bawdon RE. Pharmacokinetics of penicillin-G in serum and nasal washings of *Pasteurella multocida*-free and -infected rabbits. *Lab Anim Sci*. 1987;37:65–68.
179. Wen H, Pan B, Wang F, et al. The effect of self-licking behavior on pharmacokinetics of eprinomectin and clinical efficacy against *Psoroptes cuniculi* in topically administered rabbits. *Parasitol Res*. 2010;106:607–613.

180. Wixson SK. Anesthesia and analgesia. Manning PJ, Ringler DH, Newcomer CE. The Biology of the Laboratory Rabbit, 2nd ed, San Diego: Academic Press, 1994.

181. Yu GY, Yan CH, Yu XG, et al. Effects of chelation therapy with succimer in young rabbits of moderate lead poisoning. *Zhonghua Yu Fang Yi Xue Za Zhi*. 2009;43:8–13.

182. Zhou JY, Xu PF, Chen H, et al. Therapeutic effect of ceftazidime in a rabbit model of peritonitis caused by Escherichia coli producing CTX-M-14 extended-spectrum beta-lactamase. *Zhonghua Jie He He Hu Xi Za Zhi*. 2005;28:689–693.

CHAPTER 10

Ferrets

James K. Morrisey

TABLE 10-1 Antimicrobial and Antifungal Agents Used in Ferrets.

| Agent                                          | Dosage                                                 | Comments                                                                     |
|------------------------------------------------|--------------------------------------------------------|------------------------------------------------------------------------------|
| Amikacin                                       | 8-16 mg/kg SC, IM, IV divided q8-24h <sup>65,100</sup> | Potentially ototoxic and nephrotoxic                                         |
|                                                | 10-15 mg/kg SC, IM q12h <sup>11</sup>                  |                                                                              |
| Amoxicillin                                    | —                                                      | Can use with metronidazole and bismuth subsalicylate for <i>Helicobacter</i> |
|                                                | 20 mg/kg PO, SC q12h <sup>38</sup>                     | <i>Helicobacter</i>                                                          |
|                                                | 30 mg/kg PO q8h <sup>29</sup> × 21 days                |                                                                              |
| Amoxicillin/clavulanic acid (Clavamox, Pfizer) | 12.5 mg/kg PO q12h <sup>13</sup>                       |                                                                              |
|                                                | 13-25 mg/kg PO q8-12h <sup>38</sup>                    |                                                                              |
| Amphotericin B                                 | 0.4-0.8 mg/kg IV q7d <sup>10</sup>                     | Blastomycosis; monitor for azotemia; total dose 7-25 mg                      |
| Ampicillin                                     | 5-30 mg/kg SC, IM, IV q8-12h <sup>11,63</sup>          |                                                                              |
| Azithromycin                                   | 5 mg/kg PO q24h <sup>77</sup>                          |                                                                              |
| Cefadroxil                                     | 15-20 mg/kg PO q12h <sup>13</sup>                      |                                                                              |
| Cephalexin                                     | 15-25 mg/kg PO q12h <sup>13</sup>                      |                                                                              |
|                                                | 15-30 mg/kg PO q8h <sup>38</sup>                       |                                                                              |
| Cephaloridine                                  | 10-25 mg/kg SC, IM q24h × 5-7 days <sup>89</sup>       | Dermatitis                                                                   |
|                                                | 25-50 mg/kg PO                                         |                                                                              |



|                               |                                                                          |                                                                                                                                                                    |
|-------------------------------|--------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Chloramphenicol               | q12h <sup><a href="#">13</a></sup>                                       |                                                                                                                                                                    |
|                               | 30-50 mg/kg SC, IM, IV q12h <sup><a href="#">11,17</a></sup>             |                                                                                                                                                                    |
|                               | 50 mg/kg PO, SC, IM, IV q12h <sup><a href="#">37,38</a></sup>            | 14-day minimum for proliferative bowel disease <sup><a href="#">37,38</a></sup>                                                                                    |
| Ciprofloxacin (Cipro, Bayer)  | —                                                                        | Mix 500 mg tablet in 10 mL water (50 mg/mL)                                                                                                                        |
|                               | 5-15 mg/kg PO q12h <sup><a href="#">13</a></sup>                         | Flavor for improved acceptance                                                                                                                                     |
|                               | 10-30 mg/kg PO q24h <sup><a href="#">17</a></sup>                        |                                                                                                                                                                    |
| Clarithromycin                | 12.5 mg/kg PO q8-12h × 14 days <sup><a href="#">50,56</a></sup>          | <i>Helicobacter</i> ; use with ranitidine bismuth citrate                                                                                                          |
|                               | 50 mg/kg PO q24h or divided q12h × 14 days <sup><a href="#">63</a></sup> | <i>Helicobacter</i> ; use with omeprazole (or ranitidine) and metronidazole                                                                                        |
| Clindamycin                   | 5.5-10 mg/kg PO q12h <sup><a href="#">13</a></sup>                       | Anaerobic infections; bone and dental disease                                                                                                                      |
|                               | 12.5 mg/kg PO q12h <sup><a href="#">102</a></sup>                        | Toxoplasmosis                                                                                                                                                      |
| Cloxacillin                   | 10 mg/kg PO, IM, IV q6h <sup><a href="#">10</a></sup>                    |                                                                                                                                                                    |
| Enrofloxacin (Baytril, Bayer) | 5-10 mg/kg PO, SC, IM q12h <sup><a href="#">13</a></sup>                 | IM for short term (generally 1 injection); injectable form can be given PO in palatable liquid; <sup><a href="#">13</a></sup> liquid for PO can also be compounded |
|                               | 8.5 mg/kg PO q24h or divided q12h <sup><a href="#">50</a></sup>          | Can be used with bismuth subsalicylate for <i>Helicobacter</i>                                                                                                     |
|                               | 10-20 mg/kg PO, SC, IM q12h <sup><a href="#">100</a></sup>               |                                                                                                                                                                    |
|                               | 10-30 mg/kg PO, SC, IM q24h <sup><a href="#">86</a></sup>                |                                                                                                                                                                    |
| Erythromycin                  | 10 mg/kg PO q6h <sup><a href="#">10</a></sup>                            |                                                                                                                                                                    |
|                               | 220 g/ton feed <sup><a href="#">27</a></sup>                             | Controlling <i>Campylobacter</i> diarrhea in large groups                                                                                                          |
| Gentamicin                    | 2 mg/kg PO q12h × 10-14 days <sup><a href="#">20</a></sup>               | Parenteral form can be given PO; proliferative colitis that is nonresponsive to chloramphenicol <sup><a href="#">11,20</a></sup>                                   |
|                               | 2-4 mg/kg SC, IM, IV q12h <sup><a href="#">13</a></sup>                  | If given IV, dilute with saline and administer over 20 min                                                                                                         |
|                               | 5 mg/kg SC, IM q24h <sup><a href="#">17</a></sup>                        |                                                                                                                                                                    |
|                               |                                                                          |                                                                                                                                                                    |

|                                         |                                                                                                        |                                                                                                     |
|-----------------------------------------|--------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------|
| Griseofulvin                            | 25 mg/kg PO<br>q12 <sup><a href="#">65</a></sup> -24h <sup><a href="#">38</a></sup>                    | Refractory dermatomycosis; use with lime-sulfur dips<br>q7d <sup><a href="#">38</a></sup>           |
| Ketoconazole                            | 10-30 mg/kg PO<br>q8h <sup><a href="#">10</a></sup>                                                    |                                                                                                     |
|                                         | 10-30 mg/kg PO<br>q12-24h <sup><a href="#">100</a></sup>                                               |                                                                                                     |
|                                         | 10-50 mg/kg PO<br>q12-24h <sup><a href="#">51</a></sup>                                                |                                                                                                     |
| Lime sulfur                             | Dip q7d <sup><a href="#">38</a></sup>                                                                  | Dermatomycosis; see griseofulvin                                                                    |
| Lincomycin                              | 11 mg/kg PO q8h <sup><a href="#">13</a></sup>                                                          |                                                                                                     |
| Metronidazole                           | —                                                                                                      | Anaerobic infections; can use with amoxicillin and<br>bismuth subsalicylate for <i>Helicobacter</i> |
|                                         | 15-20 mg/kg PO<br>q12h <sup><a href="#">11</a></sup>                                                   |                                                                                                     |
|                                         | 20 mg/kg PO<br>q12h <sup><a href="#">38.39</a></sup>                                                   |                                                                                                     |
|                                         | 50 mg/kg PO<br>q24h <sup><a href="#">17</a></sup>                                                      |                                                                                                     |
| Neomycin                                | 10-20 mg/kg PO<br>q6h <sup><a href="#">10.17</a></sup>                                                 | Potential nephrotoxicity and neuromuscular blockage                                                 |
| Netilmicin<br>(Netromycin,<br>Schering) | 6-8 mg/kg SC, IM,<br>IV q24h <sup><a href="#">47</a></sup>                                             | Severe staphylococcal infections                                                                    |
| Oxytetracycline                         | 20 mg/kg PO<br>q8h <sup><a href="#">10.13.17</a></sup>                                                 |                                                                                                     |
| Penicillin G (sodium<br>or potassium)   | 20,000 U/kg IM<br>q12h <sup><a href="#">51</a></sup>                                                   |                                                                                                     |
|                                         | 40,000-44,000<br>U/kg SC, <sup><a href="#">65</a></sup> IM<br>q24h <sup><a href="#">10.11.13</a></sup> |                                                                                                     |
| Pentamidine<br>isethionate              | 3-4 mg/kg SC<br>q48h <sup><a href="#">42</a></sup>                                                     | <i>Pneumocystis pneumonia</i>                                                                       |
| Sulfadimethoxine                        | 25 mg/kg PO, SC,<br>IM q24h <sup><a href="#">13</a></sup>                                              |                                                                                                     |
|                                         | 30-50 mg/kg PO<br>q12-24h <sup><a href="#">17</a></sup>                                                |                                                                                                     |
| Sulfamethazine                          | 1-5 mg/mL<br>drinking water <sup><a href="#">62</a></sup>                                              |                                                                                                     |
| Sulfasoxazole                           | 50 mg/kg PO q8h <sup><a href="#">13</a></sup>                                                          |                                                                                                     |
|                                         |                                                                                                        |                                                                                                     |

|                         |                                            |                                 |
|-------------------------|--------------------------------------------|---------------------------------|
| Tetracycline            | 20 mg/kg PO q8h <sup>17</sup>              |                                 |
|                         | 25 mg/kg PO q12h <sup>10</sup>             |                                 |
| Trimethoprim/sulfa      | 5 mg/kg PO q24h <sup>31</sup>              | Pyelonephritis                  |
|                         | 15 mg/kg IV q12h <sup>8</sup>              |                                 |
|                         | 15-30 mg/kg PO, SC q12h <sup>38</sup>      | Dosage amount of combined drugs |
| Tylosin (Tylan, Elanco) | 5-10 mg/kg IM, IV q12h <sup>17</sup>       |                                 |
|                         | 10 mg/kg PO, SC q8-12h <sup>13,17,63</sup> |                                 |

TABLE 10-2 Antiparasitic Agents Used in Ferrets.

| Agent                           | Dosage                                                                            | Comments                               |
|---------------------------------|-----------------------------------------------------------------------------------|----------------------------------------|
| Amitraz (Mitaban, Upjohn)       | Topical to affected area q7-14d × 3-6 treatments <sup>61,63</sup>                 | Demodecosis; use full concentration    |
|                                 | 0.0125% solution q7d × 3 treatments then 0.0375% q7d × 3 treatments <sup>69</sup> | Demodecosis secondary to other illness |
| Amprolium                       | 19 mg/kg PO q24h <sup>13</sup>                                                    | Coccidiosis                            |
|                                 | 100 mg/kg PO in food or water for 7 days <sup>42</sup>                            | <i>Isospora</i>                        |
| Carbaryl powder (5%)            | Topical q7d × 3-6 treatments <sup>13</sup>                                        | Ectoparasites                          |
| Decoquate                       | 0.5 mg/kg PO for at least 2 weeks <sup>77</sup>                                   | Coccidiosis, larger groups of ferrets  |
| Fenbendazole                    | 20 mg/kg PO q24h × 5 days <sup>62</sup>                                           |                                        |
|                                 | 50 mg/kg PO q24h × 30 days <sup>1</sup>                                           | <i>Mesocestoides</i> infection         |
| Fipronil (Frontline, Merial)    | 1 pump of spray or 1/5-1/2 of cat pipette topical q60d <sup>61</sup>              | Flea adulticide                        |
|                                 | 0.2-0.4 mL topically q30d <sup>100</sup>                                          |                                        |
| Imidacloprid (Advantage, Bayer) | 1 cat dose divided onto 2-3 spots along                                           | Flea adulticide                        |

|                                                  |                                                                                  |                                                                                                      |
|--------------------------------------------------|----------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------|
|                                                  | dorsum q30d <sup>61</sup>                                                        |                                                                                                      |
|                                                  | 0.1 mL topically q30d <sup>100</sup>                                             | Use small cat/kitten vial                                                                            |
|                                                  | 0.4 mL topically q30d <sup>51</sup>                                              |                                                                                                      |
| Imidacloprid/moxidectin (Advantage Multi, Bayer) | 1.9-3.3 µg/kg topically q30d <sup>77</sup>                                       | Heartworm prevention                                                                                 |
| Ivermectin                                       | 0.05 mg/kg PO q30d <sup>38,94</sup>                                              | Heartworm preventative; administer 1 mo before and continue to 2 mo after possible mosquito exposure |
|                                                  | 0.05 mg/kg PO q30d until negative testing <sup>97</sup>                          | Recommended treatment for heartworms; give prednisolone (1 mg/kg/d) concurrently                     |
|                                                  | 0.05 mg/kg PO, SC <sup>26,94</sup>                                               | Heartworm microfilaricide; 3-4 wk postadulticide treatment                                           |
|                                                  | 0.05-0.3 mg/kg PO q24h for 1 mo after negative skin scraping <sup>8</sup>        | Demodecosis                                                                                          |
|                                                  | 0.055 mg/ferret PO q30d <sup>38</sup>                                            | Heartworm preventative (Heartgard, Merial); use small cat dose                                       |
|                                                  | 0.2-0.5 mg/kg SC q14d × 3 treatments <sup>38</sup>                               | Sarcoptic mange                                                                                      |
|                                                  | 0.4 mg/kg PO, SC, repeat in 14-28 days <sup>38,83</sup>                          | Ear mites, ticks                                                                                     |
|                                                  | 0.5-1 mg/kg in ears, repeat in 14 days <sup>13,38</sup>                          | Ear mites; half dose in each ear; treat cats and dogs in house concurrently                          |
| Lime sulfur                                      | Dip 1:40 dilution q7d × 6 wk <sup>100</sup>                                      | Demodectic mange <sup>26</sup>                                                                       |
| Lufenuron (Program, Novartis)                    | 30-45 mg/kg PO q30d <sup>47</sup>                                                | Flea larvicide                                                                                       |
| Mebendazole                                      | 50 mg/kg PO q12h × 2 days <sup>42</sup>                                          | Nematodes                                                                                            |
| Melarsomine dihydrochloride (Immiticide, Merial) | 2.5 mg/kg IM once, repeat in 30 days with 2 treatments 24 hr apart <sup>13</sup> | Heartworm adulticide; less commonly used; use prednisone (1 mg/kg q24h × 4 mo) following treatment   |
|                                                  | 15-20 mg/kg PO q12h                                                              |                                                                                                      |

|                                                          |                                                                        |                                                                                                                       |
|----------------------------------------------------------|------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------|
| Metronidazole                                            | × 14 days <sup>10</sup>                                                | Gastrointestinal protozoa                                                                                             |
| Milbemycin oxime (Interceptor, Novartis)                 | 1.15-2.33 mg/kg PO q30d <sup>91</sup>                                  | Heartworm preventative                                                                                                |
| Moxidectin                                               | 0.1 mL SC <sup>97</sup>                                                | Heartworm treatment (single dose) or prevention every 6 mo                                                            |
|                                                          | 0.17 mg SC once <sup>77</sup>                                          | Heartworm adulticide                                                                                                  |
| Paramomycin                                              | 165 mg/kg PO q12h × 5d <sup>77</sup>                                   | Cryptosporidiosis; possible treatment; use with caution, severe renal disease possible                                |
| Piperazine                                               | 50-100 mg/kg PO q14d <sup>13</sup>                                     | Intestinal nematodes                                                                                                  |
| Praziquantel (Droncit, Bayer)                            | 5-10 mg/kg PO, SC, repeat in 10 <sup>65</sup> -14d <sup>10</sup>       | Cestodes                                                                                                              |
|                                                          | 25 mg/kg PO × 3d <sup>77</sup>                                         | Trematodes                                                                                                            |
| Pyrantel pamoate                                         | 4.4 mg/kg PO, repeat in 14 days <sup>13</sup>                          |                                                                                                                       |
| Pyrethrins                                               | Topical q7d prn <sup>61</sup>                                          | Fleas; use products safe for puppies and kittens                                                                      |
| Pyrimethamine                                            | 0.5 mg/kg PO q12h <sup>42</sup>                                        | Toxoplasmosis; antiprotozoal                                                                                          |
| Selamectin (Revolution, Pfizer)                          | 6-10 mg/kg topically <sup>62,63</sup>                                  | Ectoparasites (fleas, lice, most mites except <i>Demodex</i> ); doses of up to 10-12 mg/kg have also been recommended |
|                                                          | 15 mg topically q30d <sup>21</sup>                                     | Ear mites, fleas                                                                                                      |
|                                                          | 18 mg/kg topically <sup>77</sup>                                       | Heartworm prevention                                                                                                  |
| Sulfadimethoxine                                         | 20-50 mg/kg PO q24h <sup>9</sup>                                       | Coccidia                                                                                                              |
|                                                          | 50 mg/kg PO, then 25 mg/kg q24h × 9 days <sup>10</sup>                 |                                                                                                                       |
| Thiabendazole/dexamethasone/neomycin (Tresaderm, Merial) | 2 drops in each ear q24h × 7 days, off 7 days, on 7 days <sup>73</sup> | Ear mites                                                                                                             |

TABLE 10-3 Chemical Restraint/Anesthetic Agents Used in Ferrets.

| Agent        | Dosage | Comments                     |
|--------------|--------|------------------------------|
| Acepromazine | —      | See ketamine for combination |
|              |        |                              |

|                                                                  |                                                                    |                                                                                                                                                                                                                         |
|------------------------------------------------------------------|--------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                                                                  | 0.1-0.25 mg/kg SC, IM <sup><a href="#">10,24</a></sup>             | Preanesthetic; light sedation                                                                                                                                                                                           |
|                                                                  | 0.2-0.5 mg/kg SC, IM <sup><a href="#">24</a></sup>                 | Tranquilization                                                                                                                                                                                                         |
| Alphaxalone/alphadalone (Saffan, Glaxovet)                       | 6-8 mg/kg IM <sup><a href="#">55</a></sup>                         | Anesthesia; used mostly in laboratory situations; not available in the United States                                                                                                                                    |
|                                                                  | 8-12 mg/kg IV <sup><a href="#">15</a></sup>                        |                                                                                                                                                                                                                         |
| Atipamezole (Antisedan, Pfizer)                                  | 0.4 mg/kg IM <sup><a href="#">19</a></sup>                         | Dexmedetomidine <sup><a href="#">a</a></sup> and medetomidine <sup><a href="#">a</a></sup> reversal; give same volume SC, IV, IP as medetomidine or dexmedetomidine (5× medetomidine or 10× dexmedetomidine dose in mg) |
|                                                                  | 1 mg/kg SC, IV, IP <sup><a href="#">23</a></sup>                   |                                                                                                                                                                                                                         |
| Atropine                                                         | 0.04-0.05 mg/kg SC, IM, IV <sup><a href="#">22,35,38</a></sup>     | Preanesthetic; bradycardia; hypersalivation                                                                                                                                                                             |
| Bupivacaine                                                      | 1 mg/kg epidurally <sup><a href="#">64</a></sup>                   | Epidural anesthesia/analgesia                                                                                                                                                                                           |
|                                                                  | 1-1.5 mg/kg SC infiltrate <sup><a href="#">45</a></sup>            | Local anesthesia; lasts several hours                                                                                                                                                                                   |
| Dexmedetomidine <sup><a href="#">a</a></sup> (Dexdomitor, Orion) | 0.04-0.1 mg/kg IM <sup><a href="#">64</a></sup>                    | α <sub>2</sub> agonist similar to medetomidine; not commonly used because of bradycardia and other side effects                                                                                                         |
| Diazepam                                                         | —                                                                  | See ketamine for combinations                                                                                                                                                                                           |
|                                                                  | 0.5 mg/kg PO, IM, IV q6-8h <sup><a href="#">76</a></sup>           | Smooth muscle relaxation in urethral obstruction cases                                                                                                                                                                  |
|                                                                  | 0.5-1 mg/kg/hr constant-rate infusion <sup><a href="#">4</a></sup> | Seizure control                                                                                                                                                                                                         |
|                                                                  | ≤1 mg/kg IM <sup><a href="#">11</a></sup>                          | Stimulates appetite                                                                                                                                                                                                     |
|                                                                  | 1 mg/animal IV <sup><a href="#">38</a></sup>                       | Seizure control; 1-2 boluses                                                                                                                                                                                            |
|                                                                  | 1-1.5 mg/hr continuous IV <sup><a href="#">38</a></sup>            | Status epilepticus control                                                                                                                                                                                              |
|                                                                  | 1-2 mg/kg IM <sup><a href="#">11,24</a></sup>                      | Tranquilization; seizure control <sup><a href="#">4</a></sup>                                                                                                                                                           |
| Enflurane                                                        | 2% maintenance <sup><a href="#">19</a></sup>                       | Anesthesia                                                                                                                                                                                                              |
| Etomidate                                                        | 1 mg/kg IV <sup><a href="#">45</a></sup>                           | Induction and intubation of critically ill animal                                                                                                                                                                       |
| Fentanyl citrate/fluanisone (Hypnorm, Janssen)                   | 0.3 mg/kg IM <sup><a href="#">19</a></sup>                         | Anesthesia; not available in the United States                                                                                                                                                                          |
| Fentanyl/droperidol (Innovar-Vet, Schering Plough)               | 0.15 mL/kg IM <sup><a href="#">24</a></sup>                        | Minor surgical procedures; deep sedation                                                                                                                                                                                |
| Glycopyrrolate                                                   | 0.01 mg/kg IM <sup><a href="#">35</a></sup>                        | Preanesthetic; bradycardia; hypersalivation                                                                                                                                                                             |
| Isoflurane                                                       | 5% induction; 2%-3% maintenance <sup><a href="#">11</a></sup>      | Inhalant anesthetic of choice                                                                                                                                                                                           |

|                                                                      |                                                                                 |                                                                                                                               |
|----------------------------------------------------------------------|---------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------|
| Ketamine                                                             | —                                                                               | Ketamine combinations follow                                                                                                  |
|                                                                      | 10-20 mg/kg IM <sup>24</sup>                                                    | Tranquilization                                                                                                               |
|                                                                      | ≤20 mg/kg IM <sup>35</sup>                                                      | Induction; higher doses may cause apnea                                                                                       |
|                                                                      | 30-60 mg/kg IM <sup>24</sup>                                                    | Anesthesia                                                                                                                    |
| Ketamine (K)/acepromazine (A)                                        | (K) 20-35 mg/kg + (A) 0.2-0.35 mg/kg SC, IM <sup>38</sup>                       | Anesthesia                                                                                                                    |
| Ketamine (K)/diazepam (D)                                            | (K) 10-20 mg/kg + (D) 1-2 mg/kg IM <sup>38</sup>                                | Anesthesia; poor analgesia <sup>60</sup>                                                                                      |
|                                                                      | (K) 25-35 mg/kg + (D) 2-3 mg/kg IM <sup>10,60</sup>                             |                                                                                                                               |
|                                                                      | 0.1 mL/kg IV <sup>19</sup>                                                      | Induction; will allow intubation with premedication; use equal volumes of (K) at 100 mg/mL and (D) at 5 mg/mL                 |
| Ketamine (K)/dexmedetomidine (D)                                     | (K) 5 mg/kg IM + (D) 0.03 mg/kg IM <sup>87</sup>                                | Medetomidine no longer commercially available; dexmedetomidine at half the dose of medetomidine may be effective <sup>a</sup> |
| Ketamine (K)/medetomidine (M) or dexmedetomidine (D)/butorphanol (B) | —                                                                               | Medetomidine no longer commercially available; dexmedetomidine at half the dose of medetomidine may be effective <sup>a</sup> |
|                                                                      | (K) 5 mg/kg + (M) 0.08 mg/kg or (D) 0.04 mg/kg + (B) 0.1 mg/kg IM <sup>19</sup> | Induction                                                                                                                     |
| Ketamine (K)/midazolam (M)                                           | (K) 5-10 mg/kg + (M) 0.25-0.5 mg/kg IV <sup>63</sup>                            |                                                                                                                               |
|                                                                      | 0.1 mL/kg IV <sup>19</sup>                                                      | Induction; use equal volumes of (K) at 100 mg/mL and (M) at 5 mg/mL                                                           |
| Ketamine (K)/xylazine (X)                                            | (K) 10-25 mg/kg + (X) 1-2 mg/kg IM <sup>38,60</sup>                             | Anesthesia; avoid in sick animals; <sup>38</sup> may result in cardiac arrhythmias <sup>60</sup>                              |
| Lidocaine                                                            | 1-2 mg/kg total SC <sup>45</sup>                                                | Local anesthesia; use 1-2% solution; lasts 15-30 min                                                                          |
| Midazolam (Versed, Roche)                                            | —                                                                               | See ketamine for combination                                                                                                  |
|                                                                      | 0.25-0.3 mg/kg SC, IM <sup>45</sup>                                             | Mild sedation; premedication                                                                                                  |
| Morphine                                                             | 0.1 mg/kg <sup>90</sup>                                                         | Epidural anesthesia; see <a href="#">Table 10-4</a> for analgesia                                                             |
|                                                                      | 0.01-0.03 mg/kg IM,                                                             |                                                                                                                               |

|                                            |                                     |                                                                                                                            |
|--------------------------------------------|-------------------------------------|----------------------------------------------------------------------------------------------------------------------------|
| Naloxone (Narcan, Dupont)                  | IV <sup>15</sup>                    | Reversal of opioids; up to 1 mg/kg may be used <sup>55</sup>                                                               |
|                                            | 0.04 mg/kg SC, IM, IV <sup>12</sup> |                                                                                                                            |
| Pentobarbital                              | 1-2 mg/kg PO q12h <sup>13</sup>     | Seizure control; use oral elixir                                                                                           |
| Propofol                                   | 1-3 mg/kg IV <sup>53</sup>          | Induction                                                                                                                  |
|                                            | 2-5 mg/kg IV <sup>18,19</sup>       | Induction                                                                                                                  |
|                                            | 5-8 mg/kg IV <sup>15</sup>          |                                                                                                                            |
| Sevoflurane                                | To effect <sup>63</sup>             | Anesthesia                                                                                                                 |
| Thiopental (2%)                            | 8-12 mg/kg IV <sup>18,19</sup>      | Induction                                                                                                                  |
| Tiletamine/zolazepam (Telazol, Fort Dodge) | 12-22 mg/kg IM <sup>74</sup>        | Minor surgical procedures at 22 mg/kg; recovery may be prolonged at higher doses; poor muscle relaxation; rarely indicated |
| Xylazine                                   | —                                   | See ketamine for combination                                                                                               |
|                                            | 0.1-0.5 mg/kg SC, IM <sup>65</sup>  | Tranquilization; may cause hypotension, bradycardia, and arrhythmias; use with care in sick animals                        |
| Yohimbine (Yobine, Lloyd)                  | 0.2 mg/kg IV <sup>15</sup>          | Xylazine reversal                                                                                                          |
|                                            | 0.5-1 mg/kg IM <sup>15,65,95</sup>  |                                                                                                                            |

<sup>a</sup> Dexmedetomidine (0.5 mg/mL) is an α<sub>2</sub> agonist that is the active optical enantiomer of racemic compound medetomidine; ½ the dose of medetomidine (1 mg/mL) but same volume; although the same effects would be expected as with medetomidine (not commercially available, but can be obtained through various compounding services), there is limited data on the efficacy and safety of dexmedetomidine in ferrets, and, to date, appears to have been seldom used clinically in ferrets; the effects of the v/v use of the two drugs may not be equivalent, so the dose of dexmedetomidine may need to be adjusted based on clinical response.

TABLE 10-4 Analgesic Agents Used in Ferrets.

| Agent                          | Dosage                               | Comments                                 |
|--------------------------------|--------------------------------------|------------------------------------------|
| Acetylsalicylic acid (aspirin) | 0.5-22 mg/kg PO q8-24h <sup>38</sup> | Analgesia; antiinflammatory; antipyretic |
|                                | 10-20 mg/kg PO q24h <sup>100</sup>   |                                          |



|                                         |                                                                |                                                                                                                                                                                             |
|-----------------------------------------|----------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Buprenorphine                           | 12 µg/kg epidurally <sup>a</sup>                               | Epidural analgesia/anesthesia                                                                                                                                                               |
|                                         | 0.01-0.03 mg/kg SC, IM, IV q8-12h <sup>35,55</sup>             | Analgesia                                                                                                                                                                                   |
|                                         | 0.01-0.05 mg/kg SC, IM, <sup>100</sup> IV <sup>13</sup> q8-12h |                                                                                                                                                                                             |
| Butorphanol                             | —                                                              | See ketamine ( <a href="#">Table 10-3</a> ) for anesthetic combination                                                                                                                      |
|                                         | 0.05-0.5 mg/kg SC, IM q8-12h <sup>13,55</sup>                  | Analgesia                                                                                                                                                                                   |
|                                         | 0.1-0.5 mg/kg SC, IM, IV q4-6h <sup>12,15</sup>                |                                                                                                                                                                                             |
| Carprofen (Rimadyl, Pfizer)             | 1 mg/kg PO q12-24h <sup>13</sup>                               | Nonsteroidal, antiinflammatory; use caution in animals with gastritis or enteritis                                                                                                          |
|                                         | 1-5 mg/kg PO q12-24h <sup>12</sup>                             |                                                                                                                                                                                             |
| Fentanyl citrate                        | 1.25-5 µg/kg/hr IV via constant rate infusion <sup>a</sup>     | Postoperative analgesia                                                                                                                                                                     |
|                                         | 10-30 µg/kg/hr IV via constant rate infusion <sup>a</sup>      | Perioperative analgesia, after loading dose of 5-10 µg/kg IV                                                                                                                                |
| Flunixin meglumine (Banamine, Schering) | 0.3 mg/kg PO, SC q24h <sup>13</sup>                            | Nonsteroidal antiinflammatory; use caution in animals with gastritis or enteritis; use caution in using drug more than 5 days continuously; mix injectable form with palatable syrup for PO |
|                                         | 0.5-2 mg/kg SC, IV q12-24h <sup>35</sup>                       |                                                                                                                                                                                             |
| Gabapentin                              | 3-5 mg/kg PO q8-24h <sup>64</sup>                              | Neurotropic pain; may cause sedation at higher doses                                                                                                                                        |
| Hydromorphone                           | 0.1-0.2 mg/kg SC, IM, IV <sup>51</sup>                         | Opioid                                                                                                                                                                                      |
| Ibuprofen                               | 1 mg/kg PO q12-24h <sup>63</sup>                               | Nonsteroidal antiinflammatory                                                                                                                                                               |
| Ketamine                                | 0.1-0.4 mg/kg/hr IV via constant rate infusion <sup>a</sup>    | Postoperative analgesia                                                                                                                                                                     |
|                                         | 0.3-1.2 mg/kg/hr IV via                                        |                                                                                                                                                                                             |

|                                              |                                                   |                                                                                            |
|----------------------------------------------|---------------------------------------------------|--------------------------------------------------------------------------------------------|
|                                              | constant rate infusion <sup>a</sup>               | Perioperative analgesia after 2-5 mg/kg IV loading dose                                    |
| Ketoprofen<br>(Ketofen, Fort Dodge)          | 1-3 mg/kg PO, SC, IM q24h <sup>65</sup>           | Nonsteroidal antiinflammatory; use caution with gastritis or enteritis or if using >5 days |
| Meloxicam<br>(Metacam, Boehringer Ingelheim) | 0.2 mg/kg PO, SC, IM q24h <sup>41,45</sup>        | Nonsteroidal antiinflammatory; monitor liver and kidney values                             |
| Meperidine<br>(Demerol, Winthrop-Breon)      | 5-10 mg/kg SC, IM, IV q2-4h <sup>35</sup>         | Analgesia                                                                                  |
| Morphine                                     | 0.2-2 mg/kg IM <sup>15</sup>                      | Analgesia                                                                                  |
|                                              | 0.5-5 mg/kg SC, IM q2-6h <sup>35</sup>            |                                                                                            |
| Nalbuphine<br>(Nubain, Endo Labs)            | 0.5-1.5 mg/kg IM, IV q2-3h <sup>35</sup>          | Analgesia                                                                                  |
| Oxymorphone                                  | 0.05-0.2 mg/kg SC, IM, IV q8-12h <sup>35,45</sup> | Analgesia                                                                                  |
| Pentazocine<br>(Talwin, Sanofi Winthrop)     | 5-10 mg/kg IM q4h <sup>35</sup>                   | Analgesia                                                                                  |
| Tramadol                                     | 5 mg/kg PO q12-24 <sup>45</sup>                   | Analgnesia; synergistic with NSAIDs                                                        |

<sup>a</sup> M Hawkins. Personal communication. 2011.

TABLE 10-5 Cardiopulmonary Agents Used in Ferrets.

| Agent                    | Dosage                                    | Comments                                             |
|--------------------------|-------------------------------------------|------------------------------------------------------|
| Aminophylline            | 4 mg/kg PO, IM, IV q12h <sup>13</sup>     | Bronchodilator                                       |
|                          | 4.4-6.6 mg/kg PO, IM q12h <sup>38</sup>   |                                                      |
| Atenolol (Tenormin, ICI) | 3.125-6.25 mg/kg PO q24h <sup>49,75</sup> | β-adrenergic blocker for hypertrophic cardiomyopathy |
|                          | 6.25 mg/animal PO                         |                                                      |

|                                              |                                                        |                                                                                                                  |
|----------------------------------------------|--------------------------------------------------------|------------------------------------------------------------------------------------------------------------------|
|                                              | q24h <sup>13,93</sup>                                  |                                                                                                                  |
| Atropine                                     | 0.02-0.04 mg/kg SC, IM <sup>13</sup>                   | Bradycardia                                                                                                      |
|                                              | 0.1 mg/kg IT <sup>70</sup>                             |                                                                                                                  |
| Benazepril                                   | 0.25-0.5 mg/kg PO q24h <sup>49,97</sup>                | Vasodilator; less nephrotoxic than enalapril                                                                     |
| Captopril (Capoten, Squibb)                  | 1/8 of 12.5 mg tablet/animal PO q48h <sup>38</sup>     | Vasodilator; starting dose, gradually increase to q12-24h; can cause lethargy                                    |
| Digoxin (Cardoxin, Evsco)                    | 0.005-0.01 mg/kg PO q12-24h <sup>13,83</sup>           | Positive inotrope for dilated cardiomyopathy; monitor serum levels                                               |
|                                              | 0.01 mg/kg PO q12h, start at 75% lean BW <sup>38</sup> |                                                                                                                  |
| Diltiazem (Cardizem, Marion Merrill Dow)     | 1.5-7.5 mg/kg PO q12h <sup>13,92</sup>                 | Calcium channel blocker for hypertrophic cardiomyopathy                                                          |
| Doxapram                                     | 1-2 mg/kg IV <sup>22</sup>                             | Respiratory stimulant                                                                                            |
|                                              | 5-11 mg/kg IV <sup>10</sup>                            |                                                                                                                  |
| Enalapril (Enacard, Merck)                   | 0.25-0.5 mg/kg PO q24-48h <sup>13,83,93</sup>          | Vasodilator for dilated cardiomyopathy; do not use with concurrent renal disease <sup>7</sup>                    |
|                                              | 1/8 of 2.5 mg tablet/animal PO q24h <sup>38</sup>      |                                                                                                                  |
| Epinephrine                                  | 0.02 mg/kg SC, IM, IV, IT <sup>79</sup>                | Cardiac arrest; anaphylactic reactions                                                                           |
| Furosemide                                   | 1-4 mg/kg PO, SC, IM, IV q8-12h <sup>13</sup>          | Diuretic; use high dose in fulminate heart failure                                                               |
| Nitroglycerin (2%) ointment (Nitrol, Savage) | 1/16-1/8 inch/animal q12-24h <sup>11</sup>             | Vasodilator for cardiomyopathy; apply to shaved inner thigh or pinna                                             |
| Pimobendan                                   | 0.5 mg/kg q12h <sup>97</sup>                           | Phosphodiesterase inhibitor; increases cardiac contractility with dilated cardiomyopathy or mitral valve disease |
|                                              | 0.625-1.25 mg/kg q12h <sup>49</sup>                    |                                                                                                                  |
| Propranolol (Inderal, Wyeth-Ayerst)          | 0.2-1 mg/kg PO q8-12h <sup>38</sup>                    | β-blocker for hypertrophic cardiomyopathy; may cause lethargy, loss of appetite <sup>11</sup>                    |
|                                              | 2 mg/kg PO, SC q12h <sup>10,11</sup>                   |                                                                                                                  |
| Theophylline                                 | 4.25 mg/kg PO q8-12h <sup>13</sup>                     | Bronchodilator; use elixir                                                                                       |

TABLE 10-6 Adrenal Gland Disease Agents Used in Ferrets.

| Agent                                                        | Dosage                                              | Comments                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
|--------------------------------------------------------------|-----------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Anastrozole<br>(Arimidex,<br>Astrazeneca<br>Pharmaceuticals) | 0.1 mg/kg<br>PO<br>q24h <sup>85,99</sup>            | Estrogen inhibitor; precursor hormones blocked by inhibition of aromatase enzyme; use until signs resolve then 7 days on, 7 days off, etc.; pregnant owners should avoid handling agent                                                                                                                                                                                                                                                                                                                                                 |
| Bicalutamide<br>(Casodex,<br>Astrazeneca<br>Pharmaceuticals) | 5 mg/kg<br>PO<br>q24h <sup>85,99</sup>              | Testosterone inhibitor; competitively inhibits androgen by binding to receptors in target tissues; use until clinical signs resolve then 7 days on, 7 days off, etc.; pregnant owners should avoid handling agent                                                                                                                                                                                                                                                                                                                       |
| Deoxycorticosterone<br>pivalate (DOCP)                       | 2 mg/kg<br>IM q21d <sup>32</sup>                    | Treatment of adrenal insufficiency following bilateral adrenalectomy                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
| Deslorelin<br>(Suprelorin, Peptech<br>Animal Health)         | 4.7 mg<br>implant<br>SC <sup>98</sup>               | Treatment of adrenal disease; lasts 10-18 months; not available in the United States; must be imported                                                                                                                                                                                                                                                                                                                                                                                                                                  |
| Finasteride                                                  | 5 mg/kg<br>PO q24h <sup>84</sup>                    | Treatment of prostatic enlargement; for use with adrenal disease                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
| Flutamide (Eulexin,<br>Schering)                             | 10 mg/kg<br>PO q12-<br>24h <sup>13,80</sup>         | Androgen inhibitor; reduces enlarged periurethral prostate tissue; lifetime treatment; associated with mammary tumors <sup>44</sup>                                                                                                                                                                                                                                                                                                                                                                                                     |
| Leuprolide acetate                                           | —                                                   | Long acting GnRH analog that may cause an initial stimulation then suppression of LH and FSH; palliative treatment of adrenal disease (will not resolve tumor); administer q28d until clinical signs regress, then treatment interval can be up to 6-8 wk; lifetime treatment; higher dosage may shrink prostate within 12-48 hr which may improve urine flow in cases of urethral obstruction; must be prepared in aliquots and frozen (although the effects of freezing on drug efficacy are questionable) until used; very expensive |
|                                                              |                                                     |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
|                                                              |                                                     |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
|                                                              |                                                     |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
|                                                              |                                                     |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
|                                                              |                                                     |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
| • Lupron, Depot 30<br>day (TAP)                              | 100 µg/kg<br>IM q4-<br>8wk <sup>3</sup>             |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
|                                                              | 100<br>µg/animal<br><1kg IM<br>q4-6wk <sup>43</sup> |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
|                                                              | 200<br>µg/animal<br>>1kg IM<br>q4-6wk <sup>43</sup> |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
|                                                              |                                                     |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |

|                                               |                                                                               |                                                                                                                                                                                                        |
|-----------------------------------------------|-------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| • Lupron, Depot 4 month (TAP)                 | 250 µg/kg<br>IM <sup>76</sup><br><br>2 mg/kg<br>SC, IM<br>q16wk <sup>99</sup> |                                                                                                                                                                                                        |
| Melatonin                                     | 0.5-1 mg/animal<br>PO q24h <sup>81</sup><br>prn                               | Symptomatic treatment of hyperadrenocorticism; may not affect tumor growth                                                                                                                             |
|                                               | 5.4 mg implant<br>SC <sup>67</sup>                                            | Should last 6-12 mo                                                                                                                                                                                    |
| Mitotane (o,p'-DDD) (Lysodren, Bristol-Myers) | —                                                                             | Hyperadrenocorticism; variable results and not a reliable alternative to adrenalectomy or other drugs mentioned above; results have been largely unsatisfactory and, therefore, use is not recommended |

TABLE 10-7 Miscellaneous Agents Used in Ferrets.<sup>a</sup>

| Agent                                                  | Dosage                                | Comments                                                                                    |
|--------------------------------------------------------|---------------------------------------|---------------------------------------------------------------------------------------------|
| Activated charcoal                                     | 1-3 g/kg PO <sup>82</sup>             |                                                                                             |
| Amantadine (Symmetrel, Endo Labs)                      | 6 mg/kg as aerosol q12h <sup>7</sup>  | Influenza; experimental antiviral                                                           |
| Apomorphine                                            | 0.7 mg/kg SC <sup>28</sup>            | Emetic                                                                                      |
|                                                        | 5 mg/kg SC <sup>10</sup>              | Emetic; may cause excitation                                                                |
| Atropine                                               | 5-10 mg/kg SC, IM <sup>13</sup>       | Organophosphate toxicity                                                                    |
| Azathioprine (Imuran, GlaxoSmithKline)                 | 0.9 mg/kg PO q24-72h <sup>14</sup>    | Immunosuppressive agent; may use in chronic hepatitis                                       |
| Barium (20%)                                           | 2-5 mL/kg PO <sup>39</sup>            | Gastrointestinal contrast study                                                             |
|                                                        | 15 mL/kg PO <sup>37,38</sup>          |                                                                                             |
| Bismuth subcitrate, colloidal                          | 6 mg/kg PO q12h <sup>102</sup>        | In combination with enrofloxacin at 4.25 mg/kg q12h for <i>Helicobacter</i>                 |
| Bismuth subsalicylate (Pepto-Bismol, Procter & Gamble) | 0.25 mL/kg PO q4-6h <sup>37,38</sup>  | Gastrointestinal ulcers; may help prevent <i>Helicobacter</i> colonization <sup>37,38</sup> |
|                                                        | 0.5-1 mL/kg PO q6-8h <sup>100</sup>   |                                                                                             |
|                                                        | 17.5 mg/kg PO q8-12h <sup>29,50</sup> |                                                                                             |
|                                                        |                                       |                                                                                             |

|                                                         |                                                                                         |                                                                                                                                                                                                                                   |
|---------------------------------------------------------|-----------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Bleomycin<br>(Blenoxane,<br>BristolMyersSquibb)         | 10 U/m <sup>2</sup> SC <sup><a href="#">100</a></sup>                                   | Treatment of squamous cell carcinoma                                                                                                                                                                                              |
| Calcium EDTA                                            | 20-30 mg/kg SC<br>q12h <sup><a href="#">63</a></sup>                                    | Treatment of heavy metal toxicosis                                                                                                                                                                                                |
| Chlorambucil                                            | 1 mg/kg PO <sup><a href="#">5</a></sup>                                                 | Antineoplastic; in chemotherapy protocols for lymphoma                                                                                                                                                                            |
|                                                         | 20 mg/m <sup>2</sup> PO <sup><a href="#">101</a></sup>                                  |                                                                                                                                                                                                                                   |
| Chlorpheniramine<br>(Chlor-Trimeton,<br>Squibb)         | 1-2 mg/kg PO q8-<br>12h <sup><a href="#">13,38</a></sup>                                | Antihistamine; control sneezing and coughing when they interfere with eating or sleeping <sup><a href="#">38</a></sup>                                                                                                            |
| Cimetidine<br>(Tagamet,<br>SmithKline)                  | 5-10 mg/kg PO, SC,<br>IM q8h <sup><a href="#">13,52</a></sup>                           | H <sub>2</sub> blocker; inhibits acid secretion; gastrointestinal ulcers; unpalatable; give IV (slow)                                                                                                                             |
|                                                         | 10 mg/kg PO, IV<br>q8h <sup><a href="#">37,38</a></sup>                                 |                                                                                                                                                                                                                                   |
| Cisapride<br>(Propulsid, Janssen)                       | 0.5 mg/kg PO q8-<br>12h <sup><a href="#">78</a></sup>                                   | Antiemetic; motility enhancer; not currently available in the United States; must be compounded                                                                                                                                   |
| Cobalamin                                               | 25 µg/kg SC q7d × 6<br>wk, then q14d × 6 wk,<br>then q30d <sup><a href="#">41</a></sup> | Chronic diarrhea; with cobalamin malabsorption                                                                                                                                                                                    |
| Cyclophosphamide                                        | 10 mg/kg PO, SC <sup><a href="#">12</a></sup>                                           | Antineoplastic; use at higher dose for salvage treatment of lymphoma                                                                                                                                                              |
|                                                         | 200 mg/m <sup>2</sup> PO, SC <sup><a href="#">5</a></sup>                               |                                                                                                                                                                                                                                   |
| Cyclosporine                                            | 4-6 mg/kg PO q12h <sup><a href="#">54</a></sup>                                         | Pure red cell aplasia                                                                                                                                                                                                             |
| Dexamethasone                                           | 0.5 mg/kg SC, IM,<br>IV <sup><a href="#">13</a></sup>                                   |                                                                                                                                                                                                                                   |
|                                                         | 1 mg/kg IM <sup><a href="#">38</a></sup>                                                | Post-adrenalectomy; follow with prednisone                                                                                                                                                                                        |
| Dexamethasone<br>sodium phosphate                       | 1-2 mg/kg IV <sup><a href="#">4</a></sup>                                               | Cerebral edema therapy                                                                                                                                                                                                            |
|                                                         | 2 mg/kg IM, IV <sup><a href="#">33</a></sup>                                            | Anaphylactic reaction to vaccine                                                                                                                                                                                                  |
|                                                         | 4-8 mg/kg IM, IV <sup><a href="#">13</a></sup>                                          | Shock therapy                                                                                                                                                                                                                     |
| Dextrose 50%                                            | 0.25-2 mL IV <sup><a href="#">53</a></sup>                                              | Bolus for hypoglycemia; give to effect                                                                                                                                                                                            |
|                                                         | 1.25-5% IV <sup><a href="#">53</a></sup>                                                | Infusion for hypoglycemic or inappetant animal                                                                                                                                                                                    |
| Diazoxide<br>(Proglycem, Medical<br>Market Specialties) | 5-30 mg/kg PO<br>q12h <sup><a href="#">58,84</a></sup>                                  | Insulinoma; insulin-blocker; can cause hypertension, lethargy, depression, nausea; <sup><a href="#">34</a></sup> some consider it minimally effective                                                                             |
|                                                         | 10 mg/kg PO q24h or<br>divided q8-12h <sup><a href="#">36,38</a></sup>                  |                                                                                                                                                                                                                                   |
| Diphenhydramine                                         | 0.5-2 mg/kg PO, IM,<br>IV q8-12h <sup><a href="#">13,38</a></sup>                       | Antihistamine; controls sneezing and coughing when they interfere with eating or sleeping; <sup><a href="#">38</a></sup> give at high dose IM prevaccination when previous reaction occurred or for treatment of vaccine reaction |
|                                                         |                                                                                         |                                                                                                                                                                                                                                   |

|                                                            |                                                             |                                                                                                                                    |
|------------------------------------------------------------|-------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------|
| Doxapram                                                   | 1-2 mg/kg IV <sup>22</sup><br>5-11 mg/kg IV <sup>10</sup>   | Respiratory stimulant                                                                                                              |
| Doxorubicin                                                | 1 mg/kg IV q21d × 4 treatments <sup>5</sup>                 | Antineoplastic agent; lymphoma; salvage treatment                                                                                  |
|                                                            | 20-30 mg/m <sup>2</sup> IV <sup>101</sup>                   |                                                                                                                                    |
| Epinephrine                                                | 0.02 mg/kg SC, IM, IV, <sup>79</sup> IT <sup>64</sup>       | Severe vaccine reaction; cardiac arrest                                                                                            |
| Epoetin alfa (Epogen, Amgen)                               | 50-150 U/kg PO, IM q48h <sup>13</sup>                       | Stimulates erythropoiesis; after desired PCV is reached, administer q7d for maintenance                                            |
| Famotidine (Pepcid, Merck)                                 | 0.25-0.5 mg/kg PO, SC, IV q24h <sup>13</sup>                | Inhibits acid secretion; gastrointestinal ulcers                                                                                   |
| Fludrocortisone (Florinef, SquibbMark)                     | 0.05-0.1 mg/kg PO q24h or divided q12h <sup>64</sup>        | Mineralocorticoid replacement after adrenal gland removal                                                                          |
| Flunixin meglumine (Banamine, Schering)                    | —                                                           | Nonsteroidal, antiinflammatory; see also <a href="#">Table 10-4</a>                                                                |
|                                                            | 1 mg/kg SC, IM <sup>28</sup>                                | Prevention of prostaglandin-mediated hypotension of endotoxemia                                                                    |
|                                                            | 2.5 mg/animal SC, IM q12h prn <sup>31</sup>                 | Reduce inflammation in mastitis                                                                                                    |
| Flurbiprofen sodium                                        | 1-2 drops q12-24h <sup>42</sup>                             | Ophthalmic inflammation                                                                                                            |
| Furosemide                                                 | 1-4 mg/kg PO, SC, IM, IV q8-12h <sup>7</sup>                | Diuretic                                                                                                                           |
|                                                            | 2 mg/kg PO, SC, IM, IV q8-12h <sup>38,93</sup>              |                                                                                                                                    |
| Gonadotropin-releasing hormone (GnRH) (Cystorelin, Sanofi) | 20 µg/animal SC, IM <sup>36,38</sup>                        | Termination of estrus after day 10 of estrus; repeat in 2 wk prn <sup>38</sup>                                                     |
| Hairball laxative, feline                                  | 1-2 mL/animal PO q48h <sup>11</sup>                         | Trichobezoar prophylaxis                                                                                                           |
| Heparin                                                    | 100 U/animal (0.45-1.35 kg) SC q24h × 21 days <sup>93</sup> | May be used in some heartworm treatments                                                                                           |
|                                                            | 200 U/kg SC, IM q12h × 5 days <sup>38</sup>                 | Decreases thromboembolism; start day prior to some heartworm adulticide treatments                                                 |
| Human chorionic gonadotropin (hCG)                         | —                                                           | Use 10 or more days after onset of estrus to induce ovulation and prevent hyperestrogenemia; repeat in 1-2 wk prn <sup>36,38</sup> |
|                                                            |                                                             |                                                                                                                                    |

|                                         |                                                            |                                                                                      |
|-----------------------------------------|------------------------------------------------------------|--------------------------------------------------------------------------------------|
| (Pregnyl, Organon)                      | 50-100 U/animal<br>IM <sup><a href="#">31</a></sup>        |                                                                                      |
|                                         | 100 U/animal<br>IM <sup><a href="#">36,38,59</a></sup>     |                                                                                      |
|                                         | 100-200 U/animal<br>IM <sup><a href="#">10</a></sup>       |                                                                                      |
|                                         | 1000 U/animal IM <sup><a href="#">84</a></sup>             |                                                                                      |
| Hydrocortisone sodium succinate         | 25-40 mg/kg IV <sup><a href="#">13</a></sup>               | Shock                                                                                |
| Hydrogen peroxide (3%)                  | 2.2 mL/kg PO <sup><a href="#">79</a></sup>                 | Emetic                                                                               |
| Hydroxyzine (Atarax, Roerig)            | 2 mg/kg PO q8h <sup><a href="#">10,13</a></sup>            | Antihistamine; pruritus; may cause drowsiness                                        |
| Insulin, NPH                            | 0.1 U/animal SC q12h <sup><a href="#">48</a></sup>         |                                                                                      |
|                                         | 0.5-6 U/kg (or to effect) SC <sup><a href="#">13</a></sup> | Diabetes mellitus; diabetic ketoacidosis; monitor blood glucose                      |
| Insulin, Ultralente                     | 0.1 U/animal SC q24h <sup><a href="#">84</a></sup>         | Diabetes mellitus; monitor blood glucose                                             |
| Iohexal                                 | 0.25-0.5 mL/kg <sup><a href="#">4</a></sup>                | Myelography                                                                          |
|                                         | 10 mL/kg PO <sup><a href="#">34</a></sup>                  | Gastrointestinal contrast study; can dilute 1:1 with water                           |
| Ipecac (7%)                             | 2.2-6.6 mL/animal PO <sup><a href="#">28</a></sup>         | Emetic                                                                               |
| Iron dextran                            | 10 mg/animal IM once <sup><a href="#">13</a></sup>         | Iron deficiency anemia; hemorrhage                                                   |
| Isotretinoin                            | 2 mg/kg PO q24h <sup><a href="#">5</a></sup>               | Cutaneous epitheliotropic lymphoma                                                   |
| Kaolin/pectin                           | 1-2 mL/kg PO q2-6h prn <sup><a href="#">13</a></sup>       | Gastrointestinal protectant                                                          |
| Lactulose syrup (Cephulac, Merrill Dow) | 0.15-0.75 mL/kg PO q12h <sup><a href="#">13</a></sup>      | Absorption of blood ammonia in hepatic disease; may cause soft stools at higher dose |
| L-asparaginase                          | 400 U/kg SC, IM <sup><a href="#">5</a></sup>               | Antineoplastic                                                                       |
| Loperamide                              | 0.2 mg/kg PO q12h <sup><a href="#">13</a></sup>            | Antidiarrheal                                                                        |
| Mannitol                                | 0.5-1 g/kg IV <sup><a href="#">4</a></sup>                 | Give over 20 min                                                                     |
| Methotrexate                            | 0.5 mg/kg IV <sup><a href="#">5</a></sup>                  | Antineoplastic                                                                       |
| Metoclopramide                          | 0.2-1 mg/kg PO, SC, IM q6-8h <sup><a href="#">83</a></sup> | Antiemetic; motility enhancer                                                        |
| Misoprostol                             |                                                            |                                                                                      |



|                                                      |                                                      |                                                                                                                                            |
|------------------------------------------------------|------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------|
| (Cytotech, Searle)                                   | 1-5 µg/kg PO q8h <sup>64</sup>                       | Gastric ulcers                                                                                                                             |
| Nandrolone decanoate                                 | 1-5 mg/kg IM q7d <sup>44</sup>                       | Anabolic steroid                                                                                                                           |
| Nutri-Cal (EVSCO)                                    | 1-3 mL/animal PO q6-8h <sup>38</sup>                 | Nutritional supplement                                                                                                                     |
| Omeprazole (Prilosec, Astra Merck)                   | 0.7 mg/kg PO q24h <sup>30</sup>                      | Proton-pump inhibitor; decreases gastric secretion of HCl                                                                                  |
|                                                      | 4 mg/kg PO q24h <sup>39</sup>                        | <i>Helicobacter</i> ; use with clarithromycin and metronidazole                                                                            |
|                                                      | ½ capsule/animal PO q24h × 28 days <sup>56</sup>     | <i>Helicobacter</i> ; use with clarithromycin and metronidazole                                                                            |
| Oseltamivir                                          | 5 mg/kg PO q12h × 10d <sup>7</sup>                   | Antiviral for influenza treatment                                                                                                          |
| Oxyglobin (OPK Biotech)                              | 6-15 mL/kg IV over 4h <sup>71</sup>                  | Hemoglobin polymer; anemia treatment; currently under FDA testing by new manufacturer                                                      |
| Oxytocin                                             | 0.2-3 U/kg SC, IM <sup>11</sup>                      | Expels retained fetuses; stimulates lactation <sup>11</sup>                                                                                |
| Penicillamine                                        | 10 mg/kg PO q24h <sup>42</sup>                       | Copper toxicity                                                                                                                            |
| Pet-Tinic (SmithKline)                               | 0.2 mL/kg PO q24h <sup>38</sup>                      | Nutritional/iron supplement for anemia                                                                                                     |
| Phenobarbital                                        | 1-2 mg/kg PO q8-12h <sup>51,100</sup>                | Seizure control                                                                                                                            |
|                                                      | 2-10 mg/kg/hr IV constant-rate infusion <sup>4</sup> | Seizure control if diazepam is not effective                                                                                               |
| Phenoxybenzamine (Dibenzylamine, SmithKline Beecham) | 3.75-7.5 mg/animal PO q24-72h <sup>76</sup>          | α-adrenergic antagonist; smooth muscle relaxation for urethral obstruction; potential gastrointestinal or cardiovascular side effects      |
| Potassium bromide                                    | —                                                    | Seizure control                                                                                                                            |
|                                                      | 22-30 mg/kg q24h PO <sup>4</sup>                     | Dose if used with phenobarbital                                                                                                            |
|                                                      | 70-80 mg/kg q24h PO <sup>4</sup>                     | Dose if used alone                                                                                                                         |
| Prazosin (Minipress, Pfizer)                         | 0.05-0.1 mg/kg PO q8h <sup>76</sup>                  | α-adrenergic antagonist; smooth muscle relaxation for urethral obstruction; potential for gastrointestinal and cardiovascular side effects |
| Prednisolone sodium succinate                        | 22 mg/kg IV <sup>38</sup>                            | Before blood transfusion; give slowly                                                                                                      |
|                                                      | 0.25 mg/kg PO q12h × 5 days, then 0.1                | Postoperative adrenalectomy; after initial dose of                                                                                         |

|                                                      |                                                                                           |                                                                                                                              |
|------------------------------------------------------|-------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------|
| Prednisone                                           | mg/kg q12h × 10 days <sup>38</sup>                                                        | dexamethasone                                                                                                                |
|                                                      | 0.25-1 mg/kg PO divided q12h <sup>36,38</sup>                                             | Insulinoma; gradually increase to 4 mg/kg/day prn; up to 2 mg/kg/day when given with diazoxide <sup>38</sup>                 |
|                                                      | 0.5 mg/kg PO q12h × 7-10 days, then q24h × 7-10 days, then q48h × 7-10 days <sup>64</sup> | Postoperative adrenalectomy                                                                                                  |
|                                                      | 1 mg/kg PO q24h × 7-14 days <sup>38</sup>                                                 | Use following heartworm adulticide treatment; thromboembolism                                                                |
|                                                      | 1.25-2.5 mg/kg PO q24h <sup>72</sup>                                                      | Eosinophilic gastroenteritis; treat until clinical signs abate; gradually decrease to q48h <sup>72</sup>                     |
|                                                      | 2 mg/kg PO q24h <sup>100</sup>                                                            | Paliative therapy for lymphosarcoma                                                                                          |
|                                                      | 2.2 mg/kg PO <sup>100</sup> q24h prn                                                      | Antiinflammatory for chronic inflammatory bowel disease                                                                      |
| Proligestone                                         | 50 mg SC <sup>76</sup>                                                                    | Induce ovulation when jill has been in estrus for 10 days; not available in the United States                                |
| Prostaglandin F <sub>2</sub> -α (Lutalyse, Upjohn)   | 0.1-0.5 mg/animal IM prn <sup>9</sup><br>0.5 mg/animal IM <sup>9</sup>                    | Metritis; expels necrotic debris<br><br>Can induce delivery on day 41 if only one kit; follow with 6 U oxytocin 1-4 hr later |
| Ranitidine bismuth citrate (Pylorid, Glaxo Wellcome) | 24 mg/kg PO q8h <sup>56</sup>                                                             | <i>Helicobacter</i> ; use in combination with clarithromycin; not available in the United States                             |
| Ranitidine HCl (Zantac, Glaxo Wellcome)              | 3.5 mg/kg PO q12h <sup>39</sup>                                                           | Inhibits acid secretion; gastrointestinal ulcers                                                                             |
| Saw palmetto                                         | 0.15 mL/animal PO q12h <sup>91</sup>                                                      | Homeopathy remedy used for dysuria associated with prostatic enlargement                                                     |
| Stanozolol (Winstrol, Upjohn)                        | 0.5 mg/kg PO, SC q12h <sup>10</sup>                                                       | Anemia; anabolic steroid; use with caution in hepatic disease                                                                |
| Sucralfate (Carafate, Hoechst Marion Roussel)        | 25-125 mg/kg PO q8-12h <sup>52</sup>                                                      | Gastrointestinal ulcers, give before meals; requires acidic pH                                                               |
|                                                      | 75 mg/kg PO q4-6h <sup>100</sup>                                                          |                                                                                                                              |
|                                                      | 100 mg/kg PO q8-12h <sup>51</sup>                                                         |                                                                                                                              |
|                                                      | ¼ of 1 g tablet/animal PO q6h <sup>37,38</sup>                                            |                                                                                                                              |
|                                                      | 4.25 mg/kg PO q8-                                                                         |                                                                                                                              |

|                           |                                         |                                                                                  |
|---------------------------|-----------------------------------------|----------------------------------------------------------------------------------|
| Theophylline elixir       | 12h <sup>13</sup>                       | Bronchodilator                                                                   |
| Thyroxine                 | 0.2-0.4 mg/kg q12h <sup>44</sup>        | Hypothyroidism; adjust and taper as needed                                       |
| Ursodiol (Actigall, Ciba) | 15 mg/kg PO q12h <sup>14</sup>          | Treatment of chronic hepatopathies                                               |
| Vincristine               | 0.12 mg/kg IV <sup>5</sup>              |                                                                                  |
|                           | 0.2 mg/kg IV <sup>5</sup>               |                                                                                  |
|                           | 0.75 mg/m <sup>2</sup> IV <sup>5</sup>  | Minimal myelosuppression                                                         |
| Vitamin B complex         | 1-2 mg/kg IM prn <sup>13</sup>          | Dose based on thiamine content                                                   |
| Vitamin C                 | 50-100 mg/kg PO q12h <sup>42</sup>      | Adjunct therapy for lymphoma                                                     |
| Vitamin K                 | —                                       | Use feline dosage <sup>52</sup>                                                  |
| Yeast, brewer's           | ¼-½ tsp PO q12h <sup>38</sup>           | Source of chromium to stabilize glucose and insulin for animals with insulinomas |
| Zanamivir                 | 12.5 mg/kg intranasal only <sup>7</sup> | Antiviral for influenza treatment; greater effect if used with amantadine        |

<sup>a</sup> See [Table 10-13](#) for chemotherapy protocols for lymphoma.

TABLE 10-8 Hematologic and Biochemical Values of Ferrets.<sup>16,25,40,57,66,96,102</sup>

| Measurements              | Female    | Male      |
|---------------------------|-----------|-----------|
| <b>Hematology</b>         |           |           |
| PCV (%)                   | 34.6-55   | 33.6-61   |
| RBC (10 <sup>6</sup> /μL) | 6.77-9.76 | 7.1-13.2  |
| Hgb (g/dL)                | 11.9-17.4 | 12-18.5   |
| MCV (fL)                  | 44.4-53.7 | 42.6-52.5 |
| MCH (pg)                  | 16.4-19.4 | 13.7-19.7 |
| MCHC (g/dL)               | 33.2-42.2 | 30.3-34.9 |
| WBC (10 <sup>3</sup> /μL) | 2.5-18.2  | 4.4-19.1  |
| Neutrophils (%)           | 12-84     | 11-82     |
| Band cells (%)            | 0-4.2     | 0-2.2     |
| Lymphocytes (%)           | 12-95     | 12-73     |
|                           |           |           |

|                                 |           |          |
|---------------------------------|-----------|----------|
| Monocytes (%)                   | 1-8       | 0-9      |
| Eosinophils (%)                 | 0-9       | 0-8.5    |
| Basophils (%)                   | 0-2.9     | 0-2.7    |
| Platelets (10 <sup>3</sup> /μL) | 264-910   | 297-730  |
| Reticulocytes (%)               | 2-14      | 1-12     |
| <b>Biochemistries</b>           |           |          |
| ALP (U/L)                       | 3-62      | 11-120   |
| ALT (U/L)                       | 54-280    | 54-289   |
| AST (U/L)                       | 40-120    | 28-248   |
| Bilirubin, total (mg/dL)        | 0-1       | 0-0.1    |
| BUN (mg/dL)                     | 10-45     | 11-42    |
| Calcium (mg/dL)                 | 8-10.2    | 8.3-11.8 |
| Carbon dioxide (mEq/L)          | 16.5-27.8 | 12.2-28  |
| Chloride (mEq/L)                | 112-124   | 102-126  |
| Cholesterol (mg/dL)             | 122-296   | 64-221   |
| Creatinine (mg/dL)              | 0.2-1     | 0.2-1    |
| GGT (U/L)                       | 0-5       | 0-5      |
| Glucose (mg/dL)                 | 85-207    | 62.5-198 |
| LDH (U/L)                       | —         | 241-752  |
| Lipase (U/L)                    | —         | 0-200    |
| Phosphorus (mg/dL)              | 4.2-10.1  | 4-8.7    |
| Potassium (mEq/L)               | 4.2-7.7   | 4.1-7.3  |
| Protein, total (g/dL)           | 5.1-7.2   | 5.3-7.4  |
| Albumin (g/dL)                  | 3.2-4.1   | 2.8-4.2  |
| Globulin (g/dL)                 | 2.2-3.2   | 2-4      |
| Albumin:globulin                | 1-1.6     | 0.8-2.1  |
| Sodium (mEq/L)                  | 142-156   | 137-162  |

TABLE 10-9 Biologic and Physiologic Data of Ferrets. [2,25,44,57,66,88](#)

| Parameter                         | Normal values                                       |
|-----------------------------------|-----------------------------------------------------|
| Adult body weight, male           | 1-2 kg                                              |
| Adult body weight, female         | 0.5-1 kg                                            |
| Birth weight                      | 6-12 g                                              |
| Weight at 7 days                  | 30 g average                                        |
| Weight at 14 days                 | 60-70 g                                             |
| Sexual maturity                   | 4-8 mo (usually 1 <sup>st</sup> spring after birth) |
| Reproductive cycle                | Induced ovulator                                    |
| Gestation period                  | 42 ± 2 days                                         |
| Litter size                       | 1-18 (average 8, primiparous jill 10)               |
| Weaning age                       | 6-8 wk                                              |
| Eyes open                         | 34 days                                             |
| Hearing                           | 32 days                                             |
| Life span                         | 5-8 yr (average in United States)                   |
| Food consumption                  | 43 g/kg/day                                         |
| Water consumption                 | 75-100 mL/day                                       |
| Gastrointestinal transit time     | 3-4 hr                                              |
| Enteral feeding requirements      | 2000-3000 kcal/kg/day                               |
| Dental formula                    | 2(I 3/3 C 1/1 P 3/3 M 1/2) = 34                     |
| Deciduous teeth erupt             | 20-28 days                                          |
| Permanent teeth erupt             | 50-74 days                                          |
| Canines erupt                     | 50 days                                             |
| Molars erupt (first to fourth)    | 53-74 days                                          |
| Heart rate                        | 200-400 beats/min                                   |
| Mean systolic blood pressure      | 133-161 mmHg                                        |
| Respiratory rate                  | 33-36 breaths/min                                   |
| Rectal temperature                | 37.8-40°C (100-104°F)                               |
| Blood volume                      | 60-80 mL (5-7% body weight)                         |
| Intraocular pressure              | 22.8 ± 5.5 mmHg                                     |
| Endotracheal tube size            | 2-4 mm ID                                           |
| Prothrombin time (PT)             | 8-16.5 sec                                          |
| Partial thromboplastin time (PTT) | 16-25 sec                                           |

TABLE 10-10 Urinalysis Values of Ferrets.<sup>79,96</sup>

| Parameter                                               | Male                 | Female               |
|---------------------------------------------------------|----------------------|----------------------|
| Volume (mL/24 hr)                                       | 26 (8-48)            | 28 (8-140)           |
| Sodium (mmol/24 hr)                                     | 1.9 (0.4-6.7)        | 1.5 (0.2-5.6)        |
| Potassium (mmol/24 hr)                                  | 2.9 (1-9.6)          | 2.1 (0.9-5.4)        |
| Chloride (mmol/24 hr)                                   | 2.4 (0.7-8.5)        | 1.9 (0.3-7.8)        |
| pH                                                      | 6.5-7.5 <sup>a</sup> | 6.5-7.5 <sup>a</sup> |
| Protein (mg/dL)                                         | 7-33                 | 0-32                 |
| Exogenous creatinine clearance (mL/min/kg) <sup>b</sup> | —                    | 3.32 ± 2.16          |
| Insulin clearance (mL/min/kg)                           | —                    | 3.02 ± 1.78          |

<sup>a</sup> Urine pH can vary according to diet; normal urine pH in ferrets on a high-quality, meat-based diet is approximately 6.

<sup>b</sup> Endogenous creatinine clearance (mL/min/kg) = 2.5 ± 0.93.

TABLE 10-11 Proposed Schedule of Vaccinations and Routine Prophylactic Care for Ferrets.<sup>11,16,64,79</sup>

| Age                         | Recommendation                                                                                                                                                                                                                                   |
|-----------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 4-6 wk                      | CDV <sup>a</sup> vaccination if dam is unvaccinated                                                                                                                                                                                              |
| 6-8 wk                      | CDV <sup>a,b</sup> vaccination; physical examination; fecal examination                                                                                                                                                                          |
| 10-11 wk                    | CDV <sup>a,b,c</sup> vaccination; physical examination; fecal examination                                                                                                                                                                        |
| 12-14 wk                    | CDV <sup>a,b,c</sup> vaccination; rabies vaccination; <sup>d</sup> physical examination; fecal examination (optional)                                                                                                                            |
| 4-8 mo                      | Spay/castrate; fecal examination; remove musk glands (optional); start heartworm and flea prevention (endemic areas)                                                                                                                             |
| 1 yr                        | CDV <sup>a,e</sup> booster; rabies booster; <sup>d</sup> physical examination; dental prophylaxis and fecal examination if indicated; CBC; heartworm and flea prevention                                                                         |
| 2 yr                        | CDV <sup>a,e,f</sup> booster; rabies booster; <sup>d</sup> physical examination; dental prophylaxis and fecal examination if indicated; CBC; heartworm and flea prevention                                                                       |
| 3 yr and older (every 6 mo) | CDV <sup>a,e,f</sup> booster (annual); rabies booster <sup>d</sup> (annual); physical examination; dental prophylaxis and fecal examination if indicated; CBC; serum chemistries, including fasting blood glucose; heartworm and flea prevention |

<sup>a</sup> CDV, canine distemper vaccine; Purevax (Merial) is the only CDV approved for

use in ferrets; although not approved for use in ferrets, Galaxy-D (Solvay) has also been used.

<sup>b</sup> Purevax is recommended to be administered at 8 wk then every 3 wk for 3 doses.

<sup>c</sup> Vaccinations are generally administered at 2-3 wk intervals until the ferret is 12-14 wk of age.

<sup>d</sup> Only a killed virus vaccine (Imrab 3, Rhône Merieux) should be used. Vaccines should be separated by several days to reduce vaccine reactions.

<sup>e</sup> In previously unvaccinated adults, an initial series of two vaccinations given 14-28 days apart should be given.

<sup>f</sup> Rabies and distemper titers are under evaluation and may alter the revaccination schedule of older animals.

TABLE 10-12 Clinical Signs and Treatment of Ferret Endocrine Diseases. [46,48,68,80](#)

| Disease                                          | Clinical Signs                                                                                                                                                                                                                                                                                                                                                                                                                        | Sex/Age Predilection                                                                                                                                                                                  | Diagnostic Indicators                                                                                                                                                                                                                                                                                                                  | Treatment                                                                                                                                                                                                                                                                                                | Prognosis                                                                                                                                                                                                           |
|--------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Hyperestrogenism (also see hyperadrenocorticism) | <ul style="list-style-type: none"> <li>Severity varies: pale mucous membranes, vulvar enlargement, weakness, anorexia, weight loss, alopecia of tail and abdomen, melena, petechiation</li> <li>Systolic murmur, weak pulses, tachycardia, posterior paresis, and systemic infections as disease progresses</li> <li>Progression of disease slower in adrenocortical vs. protracted estrus/ovarian remnant related disease</li> </ul> | <ul style="list-style-type: none"> <li>Can occur following protracted estrus (i.e., &gt;3 wk)</li> <li>Can occur in spayed ferrets if remnant ovarian tissue present (usually late spring)</li> </ul> | <ul style="list-style-type: none"> <li>Nonregenerative anemia</li> <li>Thrombocytopenia</li> <li>Leukopenia</li> </ul>                                                                                                                                                                                                                 | <ul style="list-style-type: none"> <li>Supportive care, transfusion (if PCV &lt;20%) and ovario-hysterectomy, or surgical excision of remnant ovarian tissue</li> <li>Some recommend initial conservative medical treatment (i.e., hCG, GnRH, supportive care) prior to surgery</li> </ul>               | <ul style="list-style-type: none"> <li>Fair to good if PCV &gt;20%</li> <li>Guarded if PCV 14%-19%</li> <li>Grave if PCV &lt;14%</li> </ul>                                                                         |
| Pancreatic endocrine neoplasia (insulinoma)      | <ul style="list-style-type: none"> <li>Episodic weakness, lethargy, hypersalivation, ataxia, posterior paresis, seizures</li> <li>Episodes frequently follow periods of exercise or fasting</li> </ul>                                                                                                                                                                                                                                | <ul style="list-style-type: none"> <li>No reported sex predilection</li> <li>Usually &gt;3 yr of age</li> </ul>                                                                                       | <ul style="list-style-type: none"> <li>Blood glucose ≤60-70 mg/dL (and frequently much lower) on multiple samples</li> <li>CBC, biochemistry values (except glucose), radiographs, and ultrasound usually WNL</li> <li>Blood insulin concentrations are not reliable, but values above 250-300 pmol/L are probably abnormal</li> </ul> | <ul style="list-style-type: none"> <li>Objective is to achieve euglycemia</li> <li>Combination of surgical excision of pancreatic nodules and medical therapy (e.g., prednisone) usually required for optimal stabilization</li> <li>Client compliance critical for effective home management</li> </ul> | <ul style="list-style-type: none"> <li>Stabilization possible with treatment, but disease is usually chronic and eventually fatal</li> <li>Tendency is to slowly metastasize (primarily within pancreas)</li> </ul> |

|                                                                     |                                                                                                                                                                                                                                                                                                                                                                                                                      |                                                                                                                                                              |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                                                                                                                                                                                                                             |
|---------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <p>Adrenocortical disease (hyperadrenocorticism)</p>                | <ul style="list-style-type: none"><li>• See hyperestrogenism</li><li>• Bilaterally symmetric alopecia starting on tail and progressing cranially</li><li>• Vulvar enlargement in &gt;90% of spayed females with this disease</li><li>• Occasional pruritus</li><li>• Prostatomegaly (resulting in dysuria, anuria)</li><li>• Adrenal gland(s) may be palpably enlarged (left gland more commonly affected)</li></ul> | <ul style="list-style-type: none"><li>• Adult spayed females and neutered males; one report in intact ferret</li><li>• Average onset 2-4 yr of age</li></ul> | <ul style="list-style-type: none"><li>• CBC, biochemistry parameters usually WNL</li><li>• Enlarged adrenal glands are rarely seen radiographically</li><li>• Ultrasonography can be diagnostic in most cases</li><li>• Elevated serum estradiol, androstenedione, and 17-OH progesterone are diagnostic</li><li>• Although seldom needed, skin biopsy may show signs consistent with endocrine disease (hyperkeratosis, epidermal thinning)</li><li>• ACTH stimulation and dexamethasone suppression tests not diagnostic</li></ul> | <ul style="list-style-type: none"><li>• Adrenalectomy of affected gland if unilateral; complete removal of larger gland and debulking of smaller gland if bilateral disease; right adrenal gland difficult to remove</li><li>• Leuprolide or melatonin may decrease clinical signs, but will not alter tumor growth; mitotane is not a reliable treatment</li><li>• Deslorelin is an implant that lasts 10-18 months; may decrease clinical signs, but will not alter tumor growth</li><li>• See Table 10-6 for other medical treatments</li></ul> | <ul style="list-style-type: none"><li>• Histologic diagnoses are generally adrenocortical adenoma or hyperplasia, rarely, adenocarcinoma</li><li>• Prognosis good with adrenalectomy</li><li>• Metastasis is rare</li></ul> |
| <ul style="list-style-type: none"><li>• Diabetes mellitus</li></ul> | <ul style="list-style-type: none"><li>• Some unpublished reports in domestic ferrets</li><li>• Polyuria, polydipsia, polyphagia, dehydration, weight loss</li></ul>                                                                                                                                                                                                                                                  | <ul style="list-style-type: none"><li>• Unknown</li></ul>                                                                                                    | <ul style="list-style-type: none"><li>• Hyperglycemia, glycosuria, ketonuria</li></ul>                                                                                                                                                                                                                                                                                                                                                                                                                                               | <ul style="list-style-type: none"><li>• Insulin (follow feline protocols)</li></ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                | <ul style="list-style-type: none"><li>• Fair with treatment</li></ul>                                                                                                                                                       |

TABLE 10-13 Chemotherapy Protocols for Lymphoma in Ferrets.<sup>a</sup>

| Protocol I <sup>11,101</sup> |     |                  |                                                    |
|------------------------------|-----|------------------|----------------------------------------------------|
| Week                         | Day | Agent            | Dosage                                             |
| 1                            | 1   | Prednisone       | 1-2 mg/kg PO q12h and continued throughout therapy |
|                              | 1   | Vincristine      | 0.025 mg/kg IV                                     |
|                              | 3   | Cyclophosphamide | 10 mg/kg PO, SC                                    |
| 2                            | 8   | Vincristine      | 0.025 mg/kg IV                                     |
| 3                            | 15  | Vincristine      | 0.025 mg/kg IV                                     |
| 4                            | 22  | Vincristine      | 0.025 mg/kg IV                                     |
|                              | 24  | Cyclophosphamide | 10 mg/kg PO, SC                                    |
| 7                            | 46  | Cyclophosphamide | 10 mg/kg PO, SC                                    |
| 9                            | 63  | Prednisone       | Gradually decrease dose to 0 over the next 4 wk    |



| Week | Agent                                              | Dosage                                           |
|------|----------------------------------------------------|--------------------------------------------------|
| 1    | Vincristine                                        | 0.025 mg/kg IV                                   |
|      | L-asparaginase                                     | 400 U/kg IP                                      |
|      | Prednisone                                         | 1 mg/kg PO q24h and continued throughout therapy |
| 2    | Cyclophosphamide                                   | 10 mg/kg SC                                      |
| 3    | Doxorubicin                                        | 1 mg/kg IV                                       |
| 4-6  | As weeks 1-3 above, but discontinue L-asparaginase | —                                                |
| 8    | Vincristine                                        | 0.025 mg/kg IV                                   |
| 10   | Cyclophosphamide                                   | 10 mg/kg SC                                      |
| 12   | Vincristine                                        | 0.025 mg/kg IV                                   |
| 14   | Methotrexate                                       | 0.5 mg/kg IV                                     |

## Protocol III

| Week | Agent                                        | Dosage                                                                       |
|------|----------------------------------------------|------------------------------------------------------------------------------|
| 1    | L-asparaginase                               | 10,000 U/m <sup>2</sup> SC                                                   |
|      | Cytosin                                      | 250 mg/m <sup>2</sup> PO, SC (in 50 mL/kg of NaCl SC)                        |
|      | Prednisone                                   | 2 mg/kg PO daily for 7 days, then q48h throughout therapy                    |
| 2    | L-asparaginase                               | 10,000 U/m <sup>2</sup> SC                                                   |
|      | Perform CBC <sup>a</sup>                     |                                                                              |
| 3    | L-asparaginase                               | 10,000 U/m <sup>2</sup> SC                                                   |
|      | Cytosar                                      | 300 mg/m <sup>2</sup> SC × 2 days (dilute 100 mg with 1 mL H <sub>2</sub> O) |
| 4    | Perform CBC <sup>a</sup>                     |                                                                              |
| 5    | Cytosin                                      | 250 mg/m <sup>2</sup> PO, SC (in 50 mL/kg of NaCl SC)                        |
| 7    | Methotrexate                                 | 0.8 mg/kg IM                                                                 |
|      | Perform CBC <sup>a</sup>                     |                                                                              |
| 8    | Perform CBC <sup>a</sup>                     |                                                                              |
| 9    | Cytosin                                      | 250 mg/m <sup>2</sup> PO, SC (in 50 mL/kg of NaCl SC)                        |
| 11   | Cytosar                                      | 300 mg/m <sup>2</sup> SC × 2 days (dilute 100 mg with 1 mL H <sub>2</sub> O) |
|      | Leukeran                                     | 1 tablet/animal PO or ½ tablet/animal PO × 2 days                            |
| 12   | Perform CBC <sup>a</sup>                     |                                                                              |
| 13   | Cytosin                                      | 250 mg/m <sup>2</sup> PO, SC (in 50 mL/kg of NaCl SC)                        |
| 15   | Procarbazine                                 | 50 mg/m <sup>2</sup> PO q24h × 14 days                                       |
| 16   | Perform CBC <sup>a</sup>                     |                                                                              |
| 17   | Perform CBC <sup>a</sup>                     |                                                                              |
| 18   | Cytosin                                      | 250 mg/m <sup>2</sup> PO, SC (in 50 mL/kg of NaCl SC)                        |
| 20   | Cytosar                                      | 300 mg/m <sup>2</sup> SC × 2 days (dilute 100 mg with 1 mL H <sub>2</sub> O) |
|      | Leukeran                                     | 1 tablet/animal PO or ½ tablet/animal PO × 2 days                            |
| 23   | Cytosin                                      | 250 mg/m <sup>2</sup> PO, SC (in 50 mL/kg of NaCl SC)                        |
| 26   | Procarbazine                                 | 50 mg/m <sup>2</sup> PO q24h × 14 days                                       |
| 27   | Perform CBC <sup>a</sup> and chemistry panel | If not in remission, continue weeks 20-26 for 3 cycles                       |

Continued

# Protocol IV

| Week             | Agent            | Dosage                                                              |
|------------------|------------------|---------------------------------------------------------------------|
| 3 days           | L-asparaginase   | 400 U/kg SC (premedicate with diphenhydramine)                      |
| 1                | Vincristine      | 0.12 mg/kg IV                                                       |
|                  | Prednisone       | 1 mg/kg PO q24h continue throughout therapy                         |
|                  | Cyclophosphamide | 10 mg/kg PO                                                         |
| 2                | Vincristine      | 0.12 mg/kg IV                                                       |
| 3                | Vincristine      | 0.12 mg/kg IV                                                       |
| 4                | Vincristine      | 0.12 mg/kg IV                                                       |
|                  | Cyclophosphamide | 10 mg/kg PO                                                         |
| 7,10,13,etc.     | Vincristine      | 0.12 mg/kg IV                                                       |
|                  | Cyclophosphamide | 10 mg/kg PO                                                         |
|                  |                  | Continue therapy every 3 wk for 1 yr, then decrease to every 4-6 wk |
| Rescue treatment | Doxorubicin      | 1-2 mg/kg IV (over 20 min)                                          |

\*CBC should be checked weekly during therapy; after therapy is discontinued, continue to monitor CBC and do physical examination at 3-mo intervals.  
 †Protocol is continued in sequence biweekly after week 14, making the therapy protocol less intensive.  
 ‡J. Mayer. No-IV chemotherapy protocol. Personal communication. 2009.  
 §If CBC shows severe myelosuppression reduce dosage by 25% for all subsequent treatments of the previously used myelosuppressive drug.

## References

- Ahlgrim KA. Personal communication; 2003.
- Andrews PLR. The physiology of the ferret. In: Fox JG, ed. *Biology and Diseases of the Ferret*. Philadelphia: Lea and Febiger; 1988:100–134.
- Antinoff N. Neoplasia in ferrets. In: Bonagura JD, ed. *Kirk’s Current Veterinary Therapy XIII: Small Animal Practice*. Philadelphia: WB Saunders Co; 2000:1149–1152.
- Antinoff N. Musculoskeletal and neurologic diseases. In: Quesenberry KE, Carpenter JW. *Ferrets, Rabbits, and Rodents: Clinical Medicine and Surgery*. 2nd ed. St Louis: WB Saunders Co; 2004:115–120.
- Antinoff N, Hahn K. Ferret oncology. *Vet Clin North Am Exotic Anim Pract*. 2004;7:579–626.
- Barron HW, Rosenthal KL. Respiratory diseases. In: Quesenberry KE,

Carpenter JW. *Ferrets, Rabbits, and Rodents: Clinical Medicine and Surgery*. 3rd ed. St Louis: Saunders/Elsevier; 2012:78–85.

7. Bartlett LW. Ferret soft tissue surgery. *Semin Avian Exotic Pet Med*. 2002;11:221–230.

8. Beaufriere H, Neta M, Smith DA. Demodectic mange associated with lymphoma in a ferret. *J Exotic Pet Med*. 2009;18:57–61.

9. Bell JA. Periparturient and neonatal diseases. In: Quesenberry KE, Carpenter JW. *Ferrets, Rabbits, and Rodents: Clinical Medicine and Surgery*. 2nd ed. St Louis: WB Saunders Co; 2004:50–57.

10. Besch-Williford CL. Biology and medicine of the ferret. *Vet Clin North Am Small Anim Pract*. 1987;17:1155–1183.

11. Brown SA. Ferrets. In: Jenkins JR, Brown SA. *A Practitioner's Guide to Rabbits and Ferrets*. Lakewood, CO: American Animal Hospital Association; 1993:43–111.

12. Brown SA. Clinical techniques in the ferret. *Semin Avian Exotic Pet Med*. 1997;6:75–85.

13. Brown SA. Ferret drug dosages. In: Antinoff N, Bauck L, Boyer TH, et al. *Exotic Formulary*. 2nd ed. Lakewood, CO: American Animal Hospital Association; 1999:43–61.

14. Burgess M, Garner M. Clinical aspects of inflammatory bowel disease in ferrets. *Exotic DVM*. 2002;4.2:29–34.

15. Cantwell SL. Ferret, rabbit, and rodent anesthesia. *Vet Clin North Am Exotic Anim Pract*. 2001;4:169–191.

16. Carpenter JW, Harms CA, Harrenstien L. Biology and medicine of the domestic ferret. an overview. *J Small Exotic Anim Med*. 1994;2:151–162.

17. Collins BR. Antimicrobial drug use in rabbits, rodents, and other small mammals. In: *Antimicrobial Therapy in Caged Birds and Exotic Pets*. Trenton:

18. Cornick-Seahorn J. Anesthesia for small animals. *Proc North Am Vet Conf*; 2001:845–847.
19. Evans AT, Springsteen KK. Anesthesia of ferrets. *Semin Avian Exotic Pet Med*. 1998;7:48–52.
20. Finkler MR. Ferret colitis. In: Kirk RW, Bonagura JD. *Kirk's Current Veterinary Therapy XI: Small Animal Practice*. Philadelphia: WB Saunders Co; 1992:1180–1181.
21. Fisher M, Beck W, Hutchinson MJ. Efficacy and safety of selamectin (Stronghold®/Revolution™) used off-label in exotic pets. *Intern J Appl Res Vet Med*. 2007;5:87–96.
22. Flecknell PA. *Laboratory Animal Anesthesia*. San Diego: Academic Press; 1987.
23. Flecknell PA. Medetomidine and atipamezole. potential uses in laboratory animals. *Lab Anim*. 1997;26:21–25.
24. Fox JG. Anesthesia and surgery. In: Fox JG, ed. *Biology and Diseases of the Ferret*. Philadelphia: Lea and Febiger; 1988:289–302.
25. Fox JG. Normal clinical and biological parameters. In: Fox JG, ed. *Biology and Diseases of the Ferret*. Philadelphia: Lea and Febiger; 1988:159–173.
26. Fox JG. Parasitic diseases. In: Fox JG, ed. *Biology and Diseases of the Ferret*. Philadelphia: Lea and Febiger; 1988:235–247.
27. Fox JG. Bacterial and mycoplasmal diseases. In: Fox JG, ed. *Biology and Diseases of the Ferret*. 2nd ed. Philadelphia: Williams & Wilkins; 1998:321–354.
28. Fox JG. Diseases of the gastrointestinal system. In: Fox JG, ed. *Biology and Diseases of the Ferret*. 2nd ed. Philadelphia: Williams & Wilkins; 1998:273–290.
29. Fox JG, Lee A. The role of *Helicobacter* species in newly recognized

gastrointestinal diseases of animals. *Lab Anim Sci.* 1997;47:222–227.

30. Fox JG, Marini RP. *Helicobacter mustelae* infection in ferrets. pathogenesis, epizootiology, diagnosis, and treatment. *Semin Avian Exotic Pet Med.* 2001;10:36–44.
31. Fox JG, Pearson RC, Bell JA. Disease of the genitourinary system. In: Fox JG, ed. *Biology and Diseases of the Ferret*. 2nd ed. Philadelphia: Williams & Wilkins; 1998:247–272.
32. Goett SD, Degner DA. Suspected adrenocortical insufficiency subsequent to bilateral adrenalectomy in a ferret. *Exotic DVM.* 2003;5.1:15–18.
33. Greenacre CB. Incidence of adverse events in ferrets vaccinated with distemper or rabies vaccine. 143 cases (1995-2001). *J Am Vet Med Assoc.* 2003;223:663–665.
34. Harrenstien L. Critical care of ferrets, rabbits, and rodents. *Semin Avian Exotic Pet Med.* 1994;3:217–228.
35. Heard DJ. Principles and techniques of anesthesia and analgesia for exotic practice. *Vet Clin North Am Small Anim Pract.* 1993;23:1301–1327.
36. Hillyer EV. Ferret endocrinology. In: Kirk RW, Bonagura JD. *Kirk's Current Veterinary Therapy XI: Small Animal Practice*. Philadelphia: WB Saunders Co; 1992:1185–1188.
37. Hillyer EV. Gastrointestinal diseases of ferrets (*Mustela putorius furo*). *J Small Exotic Anim Med.* 1992;2:44–45.
38. Hillyer EV, Brown SA. Ferrets. In: Birchard SJ, Sherding RG. *Saunders Manual of Small Animal Practice*. Philadelphia: WB Saunders Co; 1994:1317–1344.
39. Hoefler HL, Bell JA. Gastrointestinal diseases. In: Quesenberry KE, Carpenter JW. *Ferrets, Rabbits, and Rodents: Clinical Medicine and Surgery*. 2nd ed. St Louis: WB Saunders Co; 2004:25–40.

40. Hoover JP, Baldwin CA. Changes in physiologic and clinicopathologic values in ferrets from 12 to 47 weeks of age. *Comp Anim Pract*. 1998;2:40–44.
41. Hoppes SM. The senior ferret. *Vet Clin North Am Exotic Anim Pract*. 2010;13:107–121.
42. Jepson L. Ferrets. In: *Exotic Animal Medicine*. Philadelphia: Saunders/Elsevier; 2009:1–44.
43. Johnson-Delaney C. Medical therapies for ferret adrenal disease. *Semin Avian Exotic Pet Med*. 2004;13:3–7.
44. Johnson-Delaney C. Ferrets. In: *Exotic Companion Medicine Handbook*. Lake Worth, FL: Zoological Education Network; 2005:1–42.
45. Johnson-Delaney C. Ferrets. anaesthesia and analgesia. Keeble E, Meredith A. BSAVA Manual of Rodents and Ferrets. Gloucester, UK: British Small Animal Veterinary Association; 2009:245–253.
46. Kawasaki TA. Laboratory parameters in disease states in ferrets. *Proc North Am Vet Conf*; 1992:663–667.
47. Kelleher SA. Skin disease of ferrets. *Semin Avian Exotic Pet Med*. 2002;11:136–140.
48. Kolmstetter CM, Carpenter JW, Morrissey JK. Diagnosis and treatment of ferret endocrine diseases. *Vet Med*. 1995;Dec:1104–1110.
49. Kraus MS, Morrissey JK. Cardiovascular and other diseases. In: Quesenberry KE, Carpenter JW. *Ferrets, Rabbits, and Rodents: Clinical Medicine and Surgery*. 3rd ed. St Louis: Saunders/Elsevier; 2012:62–77.
50. Lennox AM. Working up mystery anemia in ferrets. *Exotic DVM*. 2004;6.3:22–26.
51. Lewington JH. Appendix. In: Lewington JH, ed. *Ferret Husbandry, Medicine and Surgery*. Oxford: Butterworth Heinemann; 2000:273–282.

52. Lightfoot TL. Common ferret syndromes. *Proc North Am Vet Conf*; 1999:839–842.
53. Longley L. Ferret anaesthesia. In: Longley L, ed. *Anaesthesia of Exotic Pets*. Philadelphia: Saunders/Elsevier; 2008:85–95.
54. Malka S, Hawkins MG, Zabolotzky SM, et al. Immune-mediated pure red cell aplasia in a domestic ferret. *J Am Vet Med Assoc*. 2010;237:695–700.
55. Marini RP, Fox JG. Anesthesia, surgery, and biomethodology. In: Fox JG, ed. *Biology and Diseases of the Ferret*. 2nd ed. Philadelphia: Williams & Wilkins; 1998:449–484.
56. Marini RP, Fox JG, Taylor NS, et al. Ranitidine bismuth citrate and clarithromycin, alone or in combination, for eradication of *Helicobacter mustelae* infection in ferrets. *Am J Vet Res*. 1999;60:1280–1286.
57. Marini RP, Otto G, Erdman S, et al. Biology and diseases of ferrets. In: Fox JG, Anderson LC, Loew FM, et al. *Laboratory Animal Medicine*. San Diego: Academic Press; 2002:483–517.
58. Marini RP, Ryden EB, Rosenblad WD, et al. Functional islet cell tumor in six ferrets. *J Am Vet Med Assoc*. 1993;202:430–433.
59. Mead RA, Joseph MM, Neirinckx S. Optimal dose of human chorionic gonadotropin for inducing ovulation in the ferret. *J Zoo Biol*. 1988;7:263–267.
60. Moreland AF, Glaser C. Evaluation of ketamine, ketamine-xylazine and ketamine-diazepam anesthesia in the ferret. *Lab Anim Sci*. 1985;35:287–290.
61. Morrissey JK. Parasites of ferrets, rabbits, and rodents. *Semin Avian Exotic Pet Med*. 1996;5:106–114.
62. Morrissey JK. Ectoparasites of ferrets and rabbits. *Proc North Am Vet Conf*; 1998:844–845.
63. Morrissey JK. Ferrets. therapeutics. Keeble E, Meredith A. *BSAVA Manual of Rodents and Ferrets*. Gloucester, UK: British Small Animal Veterinary



Association; 2009:237–244.

64. Morrisey JK. Personal observation; 2011.

65. Morrisey JK, Carpenter JW. Formulary. In: Quesenberry KE, Carpenter JW. *Ferrets, Rabbits, and Rodents: Clinical Medicine and Surgery*. 3rd ed. St Louis: Saunders/Elsevier; 2012:566–575.

66. Morrisey JK, Ramer JC. Ferrets. clinical pathology and sample collection. *Vet Clin North Am Exotic Anim Pract*. 1999;2:553–564.

67. Murray J. Melatonin implants. an option for use in the treatment of adrenal disease in ferrets. *Exotic Mam Med Surg*. 2005;3:1–6.

68. Neuwirth L, Isaza R, Bellah J, et al. Adrenal neoplasia in seven ferrets. *Vet Radiol Ultrasound*. 1993;34:340–346.

69. Noli C, VanderHorst HH, Willemse T. Demodicosis in ferrets. *Vet Quart*. 1996;18:28–31.

70. Orcutt CJ. Emergency and critical care of ferrets. *Vet Clin North Am Exotic Anim Pract*. 1998;1:99–126.

71. Orcutt CJ. Update on Oxyglobin use in ferrets. *Exotic DVM*. 2001;3.3:29–30.

72. Palley LS, Fox JG. Eosinophilic gastroenteritis in the ferret. In: Kirk RW, Bonagura JD. *Kirk's Current Veterinary Therapy XI: Small Animal Practice*. Philadelphia: WB Saunders Co; 1992:1182–1184.

73. Patterson MM, Kirchain SM. Comparison of three treatments for control of ear mites in ferrets. *Lab Anim Sci*. 1999;49:655–657.

74. Payton AJ, Pick JR. Evaluation of a combination of tiletamine and zolazepam as an anesthetic for ferrets. *Lab Anim Sci*. 1989;39:243–246.

75. Petrie JP, Morrisey JK. Cardiovascular and other diseases. In: Quesenberry KE, Carpenter JW. *Ferrets, Rabbits, and Rodents: Clinical Medicine and Surgery*. 2nd ed. St Louis: WB Saunders Co; 2004:58–71.

76. Pollock CG. Disorders of the urinary and reproductive systems. In: Quesenberry KE, Carpenter JW. *Ferrets, Rabbits, and Rodents: Clinical Medicine and Surgery*. 3rd ed. St Louis: Saunders/Elsevier; 2012:46–61.
77. Powers LV. Bacterial and parasitic diseases of ferrets. *Vet Clin North Am Exotic Anim Pract*. 2009;12:531–561.
78. Quesenberry KE. Gastrointestinal disorders of ferrets. *Proc North Am Vet Conf*; 1996:870–871.
79. Quesenberry KE. Basic approach to veterinary care. In: Hillyer EV, Quesenberry KE. *Ferrets, Rabbits, and Rodents: Clinical Medicine and Surgery*. Philadelphia: WB Saunders Co; 1997:14–25.
80. Quesenberry KE, Rosenthal KL. Endocrine diseases. In: Quesenberry KE, Carpenter JW. *Ferrets, Rabbits, and Rodents: Clinical Medicine and Surgery*. 2nd ed. Philadelphia: WB Saunders Co; 2004:79–90.
81. Ramer JC, Benson KG, Morrissey JK, et al. Effects of melatonin administration on the clinical course of adrenocortical disease in domestic ferrets. *J Am Vet Med Assoc*. 2006;229:1743–1748.
82. Richardson J, Balabuszko R. Managing ferret toxicoses. *Exotic DVM*. 2000;2.4:23–26.
83. Rosenthal K. Ferrets. *Vet Clin North Am Small Anim Pract*. 1994;24:1–23.
84. Rosenthal K. Endocrine disorders of ferrets. insulinoma and adrenal gland disease. *Annu Waltham/OSU Symp Treat Small Anim Dis: Exotics Proc* 21<sup>st</sup>;1997:35–38.
85. Rosenthal K. Adrenal gland disease in ferrets. *Proc North Am Vet Conf*; 2000:1015–1016.
86. Rosenthal K. Antibiotic treatment protocols for small mammal bacterial diseases. *Proc North Am Vet Conf*; 2000:1021–1022.
87. Rosenthal KL. Personal communication; 2011.

88. Sapienza JS, Porcher D, Collins BR, et al. Tonometry in clinically normal ferrets (*Mustela putorius furo*). *Prog Vet Comp Ophthalmol*. 1991;1:291–294.
89. Scott D. Dermatoses of pet rodents, rabbits, and ferrets. In: Scott D, Miller W, Ariffen C. *Small Animal Dermatology*. 5th ed. Philadelphia: WB Saunders Co; 1995:1127–1137.
90. Sladky KK, Horne WA, Goodrowe KL, et al. Evaluation of epidural morphine for postoperative analgesia in ferrets (*Mustela putorius furo*). *Contemp Top Lab Anim Sci*. 2000;39:33–38.
91. Stahl SJ. Personal communication; 2003.
92. Stamoulis ME. Cardiac disease in ferrets. *Semin Avian Exotic Pet Med*. 1995;4:43–48.
93. Stamoulis ME, Miller MS, Hillyer EV. Cardiovascular diseases. In: Hillyer EV, Quesenberry KE. *Ferrets, Rabbits, and Rodents: Clinical Medicine and Surgery*. Philadelphia: WB Saunders Co; 1997:63–76.
94. Supakorndej P, McCall JW, Lewis RE, et al. Biology, diagnosis, and prevention of heartworm infection in ferrets. *Proc Heartworm Symp*; 1992:59–69.
95. Sylvina TJ, Berman NG, Fox JG. Effects of yohimbine on bradycardia and duration of recumbency in ketamine/xylazine anesthetized ferrets. *Lab Anim Sci*. 1990;40:178–182.
96. Thornton PC, Wright PA, Sacra PJ, et al. The ferret, *Mustela putorius furo*, as a new species in toxicology. *Lab Anim*. 1979;13:119–124.
97. Wagner RA. Ferret cardiology. *Vet Clin North Am Exotic Anim Pract*. 2009;12:115–134.
98. Wagner RA, Piche CA, Jöchle W, et al. Clinical and endocrine responses to treatment with deslorelin acetate implants in ferrets with adrenocortical disease. *Am J Vet Res*. 2005;66:910–914.
99. Weiss C. Medical management of ferret adrenal tumors and hyperplasia. *Exotic*

DVM. 1999;1.5:38–39.

100. Williams BH. Therapeutics in ferrets. *Vet Clin North Am Exotic Anim Pract.* 2000;3:131–153.

101. Williams BH, Weiss CA. Neoplasia. In: Quesenberry KE, Carpenter JW. *Ferrets, Rabbits, and Rodents: Clinical Medicine and Surgery*. 2nd ed. St Louis: WB Saunders Co; 2004:91–106.

102. Wolf TM. Ferrets. In: Mitchell MA, Tully TN, Jr. *Manual of Exotic Pet Practice*. St Louis: Saunders/Elsevier; 2009:345–374.

# Chapter 11

## Miniature pigs

Valarie V. Tynes

TABLE 11-1 Antimicrobial Agents Used in Miniature Pigs.<sup>a</sup>

| Agent                                      | Dosage                                                   | Comments                                             |
|--------------------------------------------|----------------------------------------------------------|------------------------------------------------------|
| Amoxicillin                                | 10 mg/kg PO q8 <sup>19</sup> -12h <sup>28</sup>          |                                                      |
| Amoxicillin/clavulanate (Clavamox, Pfizer) | 11-13 mg/kg PO q12 <sup>19</sup> -24h <sup>9</sup>       |                                                      |
| Ampicillin                                 |                                                          |                                                      |
| • Sodium                                   | 10-20 mg/kg IV q6-8h <sup>11</sup>                       |                                                      |
| • Trihydrate                               | 6.5 mg/kg IM q24h <sup>9</sup>                           |                                                      |
| Apramycin (Apralan, Elanco)                | 10-20 mg/kg PO q12-24h <sup>9</sup>                      |                                                      |
| Ceftiofur (Naxcel, Pfizer)                 | 1.1-2.2 mg/kg IM q24h × 7 days <sup>5</sup>              |                                                      |
|                                            | 3-10 mg/kg IM q24h <sup>9</sup>                          | No more than 2 mL/injection site                     |
| • Long acting (Excede, Pfizer)             | 5 mg/kg IM q5-7d <sup>23</sup>                           |                                                      |
| Ceftriaxone                                | 50-75 mg/kg IM, IV q24h <sup>28</sup>                    |                                                      |
| Cephalexin                                 | 30 mg/kg PO q8-12h <sup>19</sup>                         |                                                      |
| Cephradine (Velosef, Bristol-Myers Squibb) | 25-50 mg/kg PO q12h <sup>28</sup>                        |                                                      |
| Clindamycin                                | 11-33 mg/kg q12h PO <sup>19</sup>                        | Tusk abscesses                                       |
| Enrofloxacin (Baytril, Bayer)              | 2.5-5 mg/kg IM q24h <sup>23,32</sup>                     | Extra-label use prohibited in food-producing animals |
| Florfenicol (Nuflor, Intervet)             | 20 mg/kg PO q12h or IM, IV q6-8h <sup>16</sup>           |                                                      |
|                                            | 400 mg/gal drinking water q24h × 5 days <sup>23</sup>    |                                                      |
| Gentamicin                                 | 5 mg/kg PO q24h <sup>9</sup>                             |                                                      |
|                                            | 1.1-2.2 mg/kg for 3 days in drinking water <sup>23</sup> | Colibacillosis and swine dysentery                   |

|                                 |                                                            |                                      |
|---------------------------------|------------------------------------------------------------|--------------------------------------|
| Lincomycin                      | 10 mg/kg IM q24h <sup>9</sup>                              | <i>Mycoplasma</i>                    |
|                                 | 11 mg/kg IM q12-24h <sup>23</sup>                          |                                      |
|                                 | 8.4 mg/kg q24h in drinking water × 5-10 days <sup>23</sup> | Swine dysentery                      |
| Metronidazole                   | 20 mg/kg PO q12h <sup>15</sup>                             | Prohibited in food-producing animals |
| Neomycin                        | 10 mg/kg PO q6h <sup>9</sup>                               |                                      |
| Penicillin G, procaine          | 15,000-25,000 U/kg IM q24h <sup>23</sup>                   |                                      |
|                                 | 20,000-45,000 U/kg IM q24h <sup>9</sup>                    |                                      |
|                                 | 20,000-60,000 U/kg IM q24h <sup>11</sup>                   |                                      |
| Spectinomycin (Spectam, Merial) | 6.6-22 mg/kg IM q24h <sup>11</sup>                         |                                      |
| Tetracycline                    | 10-20 mg/kg IM q24h <sup>9</sup>                           |                                      |
| • Long acting                   | 20 mg/kg IM q48h <sup>9</sup>                              |                                      |
| Trimethoprim/sulfadiazine       | 5 mg/kg IM q24h <sup>28</sup>                              |                                      |
|                                 | 25-50 mg/kg PO q24h <sup>28</sup>                          |                                      |
| Tylosin (Tylan, Elanco)         | 9 mg/kg IM q12-24h <sup>9</sup>                            |                                      |

<sup>a</sup> Not to be used in animals for human consumption.

TABLE 11-2 Antiparasitic Agents Used in Miniature Pigs.<sup>a</sup>

| Agent        | Dosage                                     | Comments                                                                                     |
|--------------|--------------------------------------------|----------------------------------------------------------------------------------------------|
| Dichlorvos   | 20 mg/kg PO <sup>2,25</sup>                |                                                                                              |
| Doramectin   | 0.3 mg/kg IM <sup>13</sup>                 | Use same as ivermectin                                                                       |
| Fenbendazole | 3 mg/kg PO q24h × 3 days <sup>13</sup>     | Whipworms                                                                                    |
|              | 10 mg/kg PO q24h × 3 days <sup>5</sup>     |                                                                                              |
| Ivermectin   | 0.3 mg/kg PO, SC, IM <sup>5,13,25</sup>    | Repeat in 10-14 days for sarcoptic mange; PO dosing ineffective for treating sarcoptic mange |
| Levamisole   | 10 mg/kg PO <sup>2</sup>                   |                                                                                              |
|              | 8 mg/kg in drinking water <sup>23,25</sup> |                                                                                              |
|              |                                            |                                                                                              |

|                                  |                                           |                                                                                                                      |
|----------------------------------|-------------------------------------------|----------------------------------------------------------------------------------------------------------------------|
| Piperazine                       | 200 mg/kg PO <sup>2</sup>                 |                                                                                                                      |
|                                  | 110 mg/kg in drinking water <sup>23</sup> |                                                                                                                      |
| Pyrantel pamoate                 | 6.6 mg/kg PO, repeat prn <sup>5</sup>     |                                                                                                                      |
|                                  | 22 mg/kg in feed, once <sup>23</sup>      | Can give ½ of this dose initially if suspect high parasite burden; in 7-10 days, repeat with full dose <sup>19</sup> |
| Sulfadimethoxine (Albon, Pfizer) | 25 mg/kg PO <sup>2</sup>                  |                                                                                                                      |

<sup>a</sup> Not to be used in animals for human consumption.

TABLE 11-3 Chemical Restraint/Anesthetic Agents Used in Miniature Pigs.<sup>a</sup>

| Agent                                                       | Dosage                                                                             | Comments                                                                                                                                                                                                           |
|-------------------------------------------------------------|------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Acepromazine                                                | 0.03-1.1 mg/kg IM <sup>5</sup>                                                     | Tranquilization                                                                                                                                                                                                    |
| Atipamezole                                                 | For IM dose, see comments                                                          | Reverses medetomidine and dexmedetomidine, and potentially other α <sub>2</sub> -adrenergic agonists; actual volume is same as volume used for medetomidine (1 mg/mL) or dexmedetomidine (0.5 mg/mL) <sup>19</sup> |
| Atropine                                                    | —                                                                                  | See detomidine for combination                                                                                                                                                                                     |
|                                                             | 0.04 mg/kg SC, IM, IV <sup>5,7</sup>                                               | Preanesthetic; reduces bradycardia and hypersalivation                                                                                                                                                             |
| Azaperone (Stresnil, Schering-Plough)                       | 0.25-0.5 mg/kg IM <sup>5</sup>                                                     | Relaxation, sedation, without ataxia                                                                                                                                                                               |
|                                                             | 2 mg/kg IM <sup>5</sup>                                                            | Sedation, with ataxia                                                                                                                                                                                              |
| Butorphanol                                                 | —                                                                                  | See detomidine, ketamine, medetomidine, tiletamine/zolazepam for combinations; see <a href="#">Table 11-4</a> for analgesic doses                                                                                  |
| Detomidine (Dormosedan, Pfizer)                             | —                                                                                  | See detomidine combinations below; see tiletamine/zolazepam for combination                                                                                                                                        |
| Detomidine (De)/butorphanol (B)                             | (De) 0.02-0.06 mg/kg + (B) 0.2-0.4 mg/kg IM <sup>20</sup>                          | Anesthesia with analgesia                                                                                                                                                                                          |
| Detomidine (De)/butorphanol (B)/midazolam (Mi)/atropine (A) | (De) 0.125 mg/kg + (B) 0.3 mg/kg + (Mi) 0.3 mg/kg + (A) 0.06 mg/kg IM <sup>7</sup> | Anesthesia; reverse detomidine with yohimbine or atipamezole, and reverse butorphanol with naloxone; can reverse midazolam with flumazenil, if needed                                                              |
| Dexmedetomidine <sup>b</sup> (Dexdomitor, Pfizer)           | —                                                                                  | May replace medetomidine in all combinations; use approx half of the dose as medetomidine <sup>19</sup>                                                                                                            |
| Diazepam                                                    | —                                                                                  | See ketamine for combination                                                                                                                                                                                       |

|                                                          |                                                                                                    |                                                                                                                                                                                                                                       |
|----------------------------------------------------------|----------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                                                          | 0.1-0.5 mg/kg<br>PO <sup><a href="#">22,32</a></sup>                                               | Calming for car trip or veterinary exam                                                                                                                                                                                               |
|                                                          | 0.5-1.5 mg/kg IV <sup><a href="#">29</a></sup>                                                     | Sedation                                                                                                                                                                                                                              |
|                                                          | 0.5-8.5 mg/kg IM <sup><a href="#">7</a></sup>                                                      | Sedation                                                                                                                                                                                                                              |
| Fentanyl/droperidol<br>(Innovar-Vet,<br>Schering-Plough) | 1 mL/10-14 kg IM <sup><a href="#">34</a></sup>                                                     | Sedation; maximum effect in 20 min                                                                                                                                                                                                    |
|                                                          | 1 mL/12-25 kg IM <sup><a href="#">5</a></sup>                                                      | Tranquilization; minor procedures                                                                                                                                                                                                     |
| Flumazenil                                               | 1 mg/10-15 mg<br>midazolam IM <sup><a href="#">7</a></sup>                                         | Midazolam reversal; use with caution if ketamine is<br>only other agent being used                                                                                                                                                    |
| Glycopyrrolate                                           | 0.005-0.01 mg/kg<br>SC, IM, IV <sup><a href="#">7</a></sup>                                        | Preanesthetic; bradycardia; hypersalivation                                                                                                                                                                                           |
| Guaifenesin<br>(G)/ketamine<br>(K)/xylazine (X)          | 0.5-1 mL/kg IV to<br>effect <sup><a href="#">12,34</a></sup>                                       | Combination prepared using (G) (5%) with (K) (1-2<br>mg/mL) and (X) (1 mg/mL); induction; maintain at 2.2<br>mL/kg/hr                                                                                                                 |
| Isoflurane                                               | 4%-5%<br>induction <sup><a href="#">5,8,14</a></sup> or to<br>effect <sup><a href="#">29</a></sup> | Recommended for sick or debilitated pigs and for those<br><8 wk of age                                                                                                                                                                |
| Ketamine                                                 | Use only in<br>combination                                                                         | Ketamine combinations follow; see guaifenesin,<br>tiletamine/zolazepam for combinations                                                                                                                                               |
|                                                          | —                                                                                                  | Used alone gets poor muscle relaxation, poor visceral<br>analgesia, and rough recovery, especially IM; use with<br>other agents; increases sympathetic tone which is very<br>useful in pig anesthesia <sup><a href="#">5,19</a></sup> |
| Ketamine<br>(K)/diazepam (D)                             | —                                                                                                  | Short-term anesthesia; prolong with (K) 2-4 mg/kg IV<br>prn; no analgesia; smoother recovery than ketamine<br>alone <sup><a href="#">5</a></sup>                                                                                      |
|                                                          | (K) 10-18 mg/kg +<br>(D) 1-2 mg/kg IM <sup><a href="#">34</a></sup>                                |                                                                                                                                                                                                                                       |
|                                                          | (D) 1-2 mg/kg IM,<br>then (K) 12-20<br>mg/kg IM <sup><a href="#">5</a></sup>                       |                                                                                                                                                                                                                                       |
| Ketamine<br>(K)/midazolam (Mi)                           | (K) 3-5 mg/kg +<br>(Mi) 0.1-0.3 mg/kg<br>IM <sup><a href="#">20</a></sup>                          |                                                                                                                                                                                                                                       |
| Ketamine<br>(K)/xylazine (X)                             | (K) 1-2 mg/kg + (X)<br>0.5 mg/kg IV <sup><a href="#">12</a></sup>                                  | Tranquilization; sedation                                                                                                                                                                                                             |
|                                                          | (K) 5-20 mg/kg +<br>(X) 1-2 mg/kg IM <sup><a href="#">7</a></sup>                                  | Anesthesia; rough recovery                                                                                                                                                                                                            |
|                                                          | (X) 2.2 mg/kg IM,<br>then (K) 12-20<br>mg/kg IM <sup><a href="#">5</a></sup>                       | Short-term anesthesia; prolong with (K) 2-4 mg/kg IV<br>prn                                                                                                                                                                           |



|                                                               |                                                                               |                                                                                                                                                                                                    |
|---------------------------------------------------------------|-------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Ketamine (K)/xylazine (X)/butorphanol (B)                     | (K) 11 mg/kg + (X) 2 mg/kg + (B) 0.22 mg/kg IM <sup>7</sup>                   | Anesthesia; butorphanol enhances analgesia                                                                                                                                                         |
| Lidocaine                                                     | Topical <sup>17</sup>                                                         | Spray onto larynx 2 min before intubation to prevent laryngospasm                                                                                                                                  |
| Lidocaine/prilocaine (EMLA cream, AstraZeneca)                | Topical <sup>17</sup>                                                         | Apply to skin at time of premedication to ease intravenous access; may take 20-30 min to take effect                                                                                               |
| Medetomidine <sup>c</sup> (Me)/butorphanol (B)/midazolam (Mi) | (Me) 0.04-0.07 mg/kg + (B) 0.15-0.3 mg/kg + (Mi) 0.08-0.3 mg/kg <sup>22</sup> | May use lower doses in calm animals; medetomidine is no longer commercially available, but can be obtained through various compounding services; see dexmedetomidine                               |
| Midazolam (Versed, Roche)                                     | —                                                                             | See detomidine, ketamine for combinations                                                                                                                                                          |
|                                                               | 0.1-0.5 mg/kg <sup>28</sup> IM                                                | Sedation                                                                                                                                                                                           |
|                                                               | 0.2-0.4 mg/kg intranasal <sup>19</sup>                                        | Sedation                                                                                                                                                                                           |
| Naloxone (P/M Naloxone, Schering-Plough)                      | 4 mg total dose IV <sup>7</sup>                                               | Narcotic reversal; given to effect prn                                                                                                                                                             |
| Nitrous oxide                                                 | —                                                                             | Nitrous oxide and oxygen at equal levels (1-2 L/min) before isoflurane induction; may help calm animal during mask induction <sup>29</sup>                                                         |
| Pentobarbital                                                 | 10 mg/kg IV to effect <sup>20</sup>                                           | Anesthesia with some analgesia                                                                                                                                                                     |
| Promazine hydrochloride                                       | 0.4-1 mg/kg IV <sup>12</sup>                                                  | Tranquilization                                                                                                                                                                                    |
|                                                               | 0.5-2 mg/kg IM <sup>12</sup>                                                  | Tranquilization                                                                                                                                                                                    |
| Thiamylal                                                     | 1.5-2.5 mg/kg IV <sup>12</sup>                                                | Induction                                                                                                                                                                                          |
| Tiletamine/zolazepam (Telazol, Fort Dodge)                    | —                                                                             | Tiletamine/zolazepam combinations follow                                                                                                                                                           |
|                                                               | —                                                                             | Poor muscle relaxation; may cause rough recovery; <sup>5,7</sup> avoid using as sole agent                                                                                                         |
| Tiletamine/zolazepam (T)/detomidine (De)/butorphanol (B)      | (T) 0.6 mg/kg + (De) 0.12 mg/kg + (B) 0.3 mg/kg IM <sup>22</sup>              | Anesthesia with good analgesia                                                                                                                                                                     |
| Tiletamine/zolazepam (T)/ketamine (K)/xylazine (X)            | —                                                                             | Reconstitute (T) (500 mg) with 2.5 mL (K) (100 mg/mL) and 2.5 mL (X) (100 mg/mL), instead of sterile water; mixture has 50 mg/mL each of tiletamine, zolazepam, ketamine, xylazine; rough recovery |
|                                                               | 0.006-0.013 mL/kg IM <sup>14</sup>                                            | Tranquilization; sedation                                                                                                                                                                          |
|                                                               | 0.022-0.044 mL                                                                |                                                                                                                                                                                                    |

|                                              |                                                      |                                                                              |
|----------------------------------------------|------------------------------------------------------|------------------------------------------------------------------------------|
|                                              | (2.2-4.4 mg/kg) IM <sup>5</sup>                      | Induction; maintain with 2.2 mg/kg IV prn                                    |
|                                              | 0.02-0.026 mL/kg IM <sup>14</sup>                    | Heavy sedation                                                               |
|                                              | 0.03 mL/kg IM <sup>19</sup>                          | Heavy sedation                                                               |
| Tiletamine/zolazepam (T)/xylazine (X)        | —                                                    | Anesthesia; rapid induction; poor muscle relaxation; may have rough recovery |
|                                              | (T) 2 mg/kg + (X) 2 mg/kg IV <sup>5</sup>            |                                                                              |
|                                              | (X) 2.2 mg/kg, then (T) 2-6 mg/kg IM <sup>7,12</sup> | Anesthesia duration of 30-40 min                                             |
| Xylazine                                     | —                                                    | See guaifenesin, ketamine, tiletamine/zolazepam for combinations             |
|                                              | 0.5-3 mg/kg IM <sup>4</sup>                          | Sedation; tranquilization; deep sedation seldom encountered                  |
| Yohimbine (Antagonil, Wildlife Laboratories) | 0.125-0.3 mg/kg IV <sup>7,22,23</sup>                | Xylazine and detomidine reversal                                             |

<sup>a</sup> Not to be used in animals for human consumption.

<sup>b</sup> Alpha-2 agonist that is the active optical enantiomer of racemic compound medetomidine; ½ the dose of medetomidine but same volume due to concentration; although the same effects would be expected as with medetomidine (now commercially off the market, but can be obtained through various compounding services), there is limited data on the efficacy and safety of dexmedetomidine in miniature pigs, and, to date, appears to have been seldom used clinically in miniature swine; the effects of the two drugs may not be equivalent, so the dose of dexmedetomidine may need to be adjusted based on clinical response.

<sup>c</sup> No longer commercially available but can be compounded at various concentrations through select compounding pharmacies (i.e., Diamondback Drugs, [www.diamondbackdrugs.com](http://www.diamondbackdrugs.com); Wildlife Pharmaceuticals, [www.wildpharm.com](http://www.wildpharm.com)).

TABLE 11-4 Analgesic Agents Used in Miniature Pigs.<sup>a</sup>

| Agent | Dosage | Comments                                           |
|-------|--------|----------------------------------------------------|
|       |        | Also antiinflammatory and antipyretic; use enteric |

|                                                                        |                                                                                                  |                                                                                                                                                                   |
|------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Aspirin                                                                | 10 mg/kg PO q6-8h <sup><a href="#">20</a></sup>                                                  | coated tablets                                                                                                                                                    |
| Buprenorphine                                                          | 0.005-0.01 mg/kg IM q12h <sup><a href="#">10</a></sup> , IV q8-12h <sup><a href="#">17</a></sup> |                                                                                                                                                                   |
|                                                                        | 0.01-0.05 mg/kg SC, IM, IV q6-12h <sup><a href="#">20</a></sup>                                  |                                                                                                                                                                   |
| Butorphanol                                                            | 0.05-0.2 mg/kg SC, IV q3-4h <sup><a href="#">10</a></sup>                                        |                                                                                                                                                                   |
|                                                                        | 0.2-0.4 mg/kg SC, IM, IV q2-6h <sup><a href="#">20</a></sup>                                     |                                                                                                                                                                   |
| Carprofen <sup><a href="#">b</a></sup>                                 | 2.2 mg/kg q12h PO <sup><a href="#">20</a></sup>                                                  |                                                                                                                                                                   |
|                                                                        | 2-4 mg/kg q24h SC, IV <sup><a href="#">17</a></sup>                                              |                                                                                                                                                                   |
|                                                                        | 4.4 mg/kg q24h PO <sup><a href="#">20</a></sup>                                                  |                                                                                                                                                                   |
| Dexamethasone                                                          | 0.01-0.04 mg/kg IM, IV q24h <sup><a href="#">20</a></sup>                                        | Antiinflammatory used in treating arthritis                                                                                                                       |
|                                                                        | 0.07-0.15 mg/kg PO q12-24h <sup><a href="#">20</a></sup>                                         | Antiinflammatory used in treating arthritis                                                                                                                       |
| Etodolac <sup><a href="#">b</a></sup>                                  | 10-15 mg/kg PO q24h <sup><a href="#">20</a></sup>                                                |                                                                                                                                                                   |
| Fentanyl                                                               | 0.02-0.05 mg/kg IM, IV <sup><a href="#">17</a></sup>                                             |                                                                                                                                                                   |
| Fentanyl, transdermal patch                                            | 12 or 25 µg/hr/25-80 kg <sup><a href="#">20</a></sup>                                            | Intense or prolonged pain or when oral or injectable analgesics are not an option; apply 12 hr before surgery; <sup><a href="#">20</a></sup> may last up to 72 hr |
| Flunixin meglumine (Banamine, Schering Plough)                         | 0.5-1 mg/kg SC, IV q12-24h <sup><a href="#">10</a></sup>                                         |                                                                                                                                                                   |
|                                                                        | 1.1 mg/kg SC, IM, IV q12-24h <sup><a href="#">20</a></sup>                                       |                                                                                                                                                                   |
| Hydromorphone                                                          | 0.1-0.2 mg/kg IV q2h <sup><a href="#">20</a></sup>                                               |                                                                                                                                                                   |
|                                                                        | 0.2 mg/kg SC, IM q4-6h <sup><a href="#">20</a></sup>                                             |                                                                                                                                                                   |
| Ibuprofen <sup><a href="#">b</a></sup>                                 | 10 mg/kg PO q6-8h <sup><a href="#">20</a></sup>                                                  |                                                                                                                                                                   |
| Ketoprofen <sup><a href="#">b</a></sup>                                | 1 mg/kg PO q24h up to 5 days <sup><a href="#">20</a></sup>                                       |                                                                                                                                                                   |
|                                                                        | 3 mg/kg SC, IM, IV q24h <sup><a href="#">20</a></sup>                                            |                                                                                                                                                                   |
| Meloxicam <sup><a href="#">b</a></sup> (Metacam, Boehringer Ingelheim) | 0.1 mg/kg PO q24h <sup><a href="#">20</a></sup>                                                  |                                                                                                                                                                   |
|                                                                        | 0.4 mg/kg IM q24h <sup><a href="#">20</a></sup>                                                  |                                                                                                                                                                   |

|                                                     |                                                                               |                                             |
|-----------------------------------------------------|-------------------------------------------------------------------------------|---------------------------------------------|
| Meperidine<br>(Demerol, Winthrop<br>Breon)          | 2-10 mg/kg IM q4h <sup>10</sup>                                               |                                             |
| Morphine                                            | 0.05-0.1 mg/kg IV prn <sup>19</sup>                                           |                                             |
|                                                     | 0.1-0.2 mg/kg (max dose<br>20 mg) IM q4h or<br>prn <sup>10,19</sup>           |                                             |
| Oxymorphone                                         | 0.1-0.2 mg/kg SC, IM,<br>IV, re-dose at 0.05-0.1<br>mg/kg q1-2h <sup>20</sup> |                                             |
| Pentazocine<br>(Talwin-V,<br>Pharmacia &<br>Upjohn) | 2-5 mg/kg IM q4h <sup>10,17</sup>                                             |                                             |
| Phenylbutazone                                      | 4 mg/kg IV q24h <sup>23</sup>                                                 | Also antiinflammatory and antipyretic       |
|                                                     | 4-8 mg/kg PO q12h <sup>28</sup>                                               |                                             |
| Prednisone                                          | 0.5-1 mg/kg PO q12-24h<br>initially, then taper to<br>q48h <sup>20</sup>      | Antiinflammatory used in treating arthritis |
| Tramadol                                            | 2-4 mg/kg PO q6h-24h <sup>20</sup>                                            |                                             |

<sup>a</sup> Not to be used in animals for human consumption.

<sup>b</sup> Potential exists for gastrointestinal upset and gastric ulcers, but these are uncommon in the pet pig; should be given with food and gastrointestinal protectants.

TABLE 11-5 Miscellaneous Agents Used in Miniature Pigs.<sup>a</sup>

| Agent                                                | Dosage                               | Comments                              |
|------------------------------------------------------|--------------------------------------|---------------------------------------|
| Attapulgate<br>(Kaopectate,<br>Upjohn)               | 2.2 mL/kg PO <sup>2</sup>            | Gastrointestinal protectant; diarrhea |
| Dantrolene sodium<br>(Dantrium, Procter<br>& Gamble) | 1-3 mg/kg IV <sup>23</sup>           | Treatment of malignant hyperthermia   |
|                                                      | 2-5 mg/kg PO, IV<br>q8h <sup>8</sup> | Malignant hyperthermia                |
|                                                      | 5 mg/kg PO <sup>23</sup>             | Prevent malignant hyperthermia        |
| Dexamethasone                                        | 0.1 mg/kg IM, IV <sup>21</sup>       | Shock; laryngeal edema                |
| Dextrose                                             | —                                    | Hypoglycemic neonate                  |

|                                                                |                                                                                            |                                                                                                                                                                                                                         |
|----------------------------------------------------------------|--------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                                                                | 20 mL/kg of 5% solution IP <sup>5</sup>                                                    |                                                                                                                                                                                                                         |
|                                                                | 10 mL/kg of 10% solution IP <sup>5</sup>                                                   |                                                                                                                                                                                                                         |
| Famotidine                                                     | 0.1-0.2 mg/kg PO, SC, IM, IV q12h <sup>19</sup>                                            | Reduce gastric acid secretion                                                                                                                                                                                           |
| Glucosamine (G)/chondroitin sulfate (C)                        | (G) 4 mg/kg + (C) 1.3 mg/kg q12h <sup>20</sup>                                             | Maintenance dose                                                                                                                                                                                                        |
|                                                                | (G) 12 mg/kg + (C) 3.8 mg/kg PO q12h for 4 wk <sup>20</sup>                                | Initial dose                                                                                                                                                                                                            |
| Hydrogen peroxide                                              | 1 mL/5 kg PO <sup>29</sup>                                                                 | Induces vomiting; some animals may require larger dose                                                                                                                                                                  |
| Ipecac syrup                                                   | 7-15 mL/animal PO <sup>29</sup>                                                            | Induces vomiting                                                                                                                                                                                                        |
| Iron dextran                                                   | 25 mg/animal IM <sup>15</sup> in first few days of life; may repeat in 2-3 wk <sup>5</sup> | Iron deficiency in baby pigs; uncommon in miniature pigs                                                                                                                                                                |
| Metoclopramide                                                 | 0.2-0.5 mg/kg q6-8h PO, IM, IV <sup>19</sup>                                               | Prevent postoperative ileus; start with the lower end of the dose to prevent cramping                                                                                                                                   |
| Oxytocin                                                       | 5-10 U/animal IM <sup>23</sup>                                                             | Dystocia, if not obstructed                                                                                                                                                                                             |
|                                                                | 10-20 U/animal <sup>3</sup> IM                                                             | Dystocia, if not obstructed                                                                                                                                                                                             |
| Pentobarbital                                                  | 1 mL/5 kg <sup>19</sup>                                                                    | Euthanasia                                                                                                                                                                                                              |
| Polysulfated glycosaminoglycan (Adequan, Novartis)             | 4.4 mg/kg IM once, then 3.3 mg/kg q4d × 7 treatments <sup>15</sup>                         | May not see results until after 3-4 treatments; if good clinical results after first 8 treatments, then decrease frequency to weekly for 1 month, then 2× monthly, then monthly as needed for maintenance <sup>15</sup> |
| Prostaglandin F <sub>2</sub> -α (Lutalyse, Pharmacia & Upjohn) | 5 mg/animal <sup>3</sup> IM                                                                | Induces parturition in 24-30 hr when given within 3 days of expected parturition; causes abortion after 12 days of gestation                                                                                            |

<sup>a</sup> Not to be used in animals for human consumption.

TABLE 11-6 Hematologic and Serum Biochemical Values of Miniature Pigs.<sup>6</sup>

| Measurement | Mean (Reference Range) <sup>a</sup> |
|-------------|-------------------------------------|
|-------------|-------------------------------------|

| Hematology                        |                 |
|-----------------------------------|-----------------|
| PCV (%)                           | 36 (22-50)      |
| RBC (10 <sup>6</sup> /μL)         | 5.7 (3.6-7.8)   |
| Hgb (g/dL)                        | 12 (7.8-16.2)   |
| MCV (fL)                          | 63 (55-71)      |
| MCH (pg)                          | 21 (18-24)      |
| MCHC (g/dL)                       | 33.5 (31-36)    |
| Platelets (10 <sup>3</sup> /μL)   | 310 (204-518)   |
| WBC (10 <sup>3</sup> /μL)         | 11.5 (5.2-17.9) |
| Neutrophils (10 <sup>3</sup> /μL) | 5.7 (0-11.4)    |
| Band cells (10 <sup>3</sup> /μL)  | 0.03 (0-0.19)   |
| Lymphocytes (10 <sup>3</sup> /μL) | 5.3 (0.8-9.8)   |
| Monocytes (10 <sup>3</sup> /μL)   | 0.2 (0-0.67)    |
| Eosinophils (10 <sup>3</sup> /μL) | 0.14 (0-0.73)   |
| Basophils (10 <sup>3</sup> /μL)   | 0.15 (0-0.61)   |
| Fibrinogen (g/L)                  | 2 (1-4)         |
| Chemistries                       |                 |
| ALP (U/L)                         | 65 (27-160)     |
| ALT (U/L)                         | 53 (11-95)      |
| AST (U/L)                         | 32 (16-64)      |
| Bilirubin, total (mg/dL)          | 0.25 (0.2-0.45) |
| BUN (mg/dL)                       | 9.7 (4.2-15.1)  |
| Chloride (mEq/L)                  | 110 (106-113)   |
| Creatine kinase (U/L)             | 701 (213-2852)  |
| Creatinine (mg/dL)                | 1.7 (1-2.3)     |
| GGT (U/L)                         | 35 (15-56)      |
| Glucose (mg/dL)                   | 105 (60-175)    |
| Potassium (mEq/L)                 | 4.3 (3.7-5)     |
|                                   |                 |

|                          |               |
|--------------------------|---------------|
| Protein, total (g/dL)    | 7.7 (6.6-8.9) |
| Albumin (g/dL)           | 4.3 (3.6-5)   |
| Sodium (mEq/L)           | 144 (139-149) |
| TCO <sub>2</sub> (mEq/L) | 24 (8-31)     |

<sup>a</sup> *n* = 100, 2- to 10-year-old healthy, Vietnamese potbellied pigs.

TABLE 11-7 Urinalysis Reference Values for Miniature Pigs.[1](#),[13](#),[19](#),[33](#)

| Parameter                   | Reference Value                                                            |
|-----------------------------|----------------------------------------------------------------------------|
| Specific gravity            | 1.010-1.050                                                                |
| pH                          | 6.9 (range 5-8)                                                            |
| Color                       | Yellow-dark amber; may be slightly cloudy                                  |
| Protein                     | Negative to trace                                                          |
| Red blood cells (per HPF)   | 0-5                                                                        |
| White blood cells (per HPF) | 0-5                                                                        |
| Crystals                    | Occasional diet associated calcium oxalate or triple phosphate crystals    |
| Bacteria                    | Numerous in voided samples; only significant if numerous WBCs also present |

TABLE 11-8 Biologic and Physiologic Data of Miniature Pigs.[5](#)

| Parameter                      | Value                                                        |
|--------------------------------|--------------------------------------------------------------|
| Life expectancy                | 8-20 years <a href="#">13</a> (avg 15-18) <a href="#">19</a> |
| Respiratory rate (breaths/min) |                                                              |
| Newborn                        | 50-60                                                        |
| Weaned pigs                    | 25-40                                                        |
| 10-15 wk                       | 30-40                                                        |
| 15-26 wk                       | 25-35                                                        |

|                                  |                                                                                                       |
|----------------------------------|-------------------------------------------------------------------------------------------------------|
| Sows, boars                      | 13-18                                                                                                 |
| Heart rate (beats/min)           |                                                                                                       |
| Newborn                          | 200-250                                                                                               |
| Weaned pigs                      | 90-100                                                                                                |
| 10-15 wk                         | 80-90                                                                                                 |
| 15-26 wk                         | 75-85                                                                                                 |
| Sows, boars                      | 70-80                                                                                                 |
| Rectal temperature <sup>18</sup> | 37.6°C (99.7°F); diurnal variation in body temperature exists; temperature decreases as age increases |
| Weight                           |                                                                                                       |
| Birth                            | 250-450 g                                                                                             |
| Adult <sup>30</sup>              | 34-91 kg (avg 55)                                                                                     |
| Reproduction                     |                                                                                                       |
| Puberty                          |                                                                                                       |
| • Boars<br><br>• Gilts           | 3 mo of age                                                                                           |
|                                  | 3.5-4 mo of age                                                                                       |
| Estrous cycle                    | 18-24 days (avg 21)                                                                                   |
| Standing heat duration           | 1-3 days                                                                                              |



|                                                                           |                                |
|---------------------------------------------------------------------------|--------------------------------|
|                                                                           |                                |
| Ovulation                                                                 |                                |
| <ul style="list-style-type: none"> <li>• Gilts</li> <li>• Sows</li> </ul> | 24-36 hr after onset of estrus |
|                                                                           | 30-44 hr after onset of estrus |
| Gestation length                                                          | 112-116 days (avg 114)         |
| Litter size                                                               | 4-15 piglets (avg 6-8)         |

TABLE 11-9 Preventive Medicine Recommendations for Miniature Pigs.
 [4](#),[13](#),[24](#),[26](#),[31](#)

| Minimum Recommended Vaccinations                     |                                                                                                              |
|------------------------------------------------------|--------------------------------------------------------------------------------------------------------------|
| Pet pigs                                             |                                                                                                              |
| Erysipelas                                           | 8-12 wk of age; repeat in 3 wk; revaccinate semiannually or annually                                         |
| Leptospirosis                                        | 8-12 wk of age; repeat in 3 wk; revaccinate semiannually or annually                                         |
| Pneumonia ( <i>Actinobacillus pleuropneumoniae</i> ) | 8-12 wk of age; repeat in 3 wk; revaccinate semiannually or annually                                         |
| Breeder pigs                                         |                                                                                                              |
| Erysipelas                                           | 8-12 wk of age; repeat in 3 wk; revaccinate 3 wk before breeding                                             |
| Leptospirosis                                        | 8-12 wk of age; repeat in 3 wk; revaccinate 3 wk before breeding                                             |
| Parvovirus                                           | 5-6 mo of age; repeat in 3 wk; revaccinate 3-8 wk before breeding; boars should be revaccinated semiannually |
|                                                      |                                                                                                              |

|                                                                                                      |                                                                                                                                                             |
|------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Pneumonia ( <i>Actinobacillus pleuropneumoniae</i> )                                                 | Sows: 5 and 2 wk before farrowing                                                                                                                           |
|                                                                                                      | Piglets: 3-8 wk of age; repeat in 3 wk                                                                                                                      |
| <b>Selected Disease Vaccinations</b>                                                                 |                                                                                                                                                             |
| Colibacillosis (baby pig scours) ( <i>E. coli</i> )                                                  | Sows: 5 and 2 wk before first farrowing, and 2 wk before each subsequent farrowing                                                                          |
| Other enteritides (rotavirus, TGE virus, <i>Clostridium</i> , <i>Salmonella</i> )                    | Sows: 5 and 2 wk before farrowing                                                                                                                           |
| Atrophic rhinitis ( <i>Bordetella bronchiseptica</i> , <i>Pasteurella multocida</i> [types A and D]) | Sows: 7 and 3 wk before first farrowing, and 3 wk before each subsequent farrowing                                                                          |
|                                                                                                      | Piglets: 1 wk of age; repeat in 3 wk                                                                                                                        |
|                                                                                                      | Boars: semiannually or annually                                                                                                                             |
| Pneumonia ( <i>Mycoplasma hyopneumoniae</i> )                                                        | Sows: 5 and 2 wk before first farrowing, and 2 wk before each subsequent farrowing                                                                          |
|                                                                                                      | Piglets: 1 wk of age; repeat in 2-3 wk                                                                                                                      |
|                                                                                                      | Boars: semiannually or annually                                                                                                                             |
| Tetanus toxoid                                                                                       | Vaccinate after surgery or trauma or annually when exposure is likely                                                                                       |
| Tetanus antitoxin                                                                                    | Administer 500-1500 U (depending on body weight) after surgery, dental procedure, or trauma; if not current on tetanus vaccine and where exposure is likely |
| <b>Neonatal Care</b>                                                                                 |                                                                                                                                                             |
| Preferred environmental temperature at 1-7 days of age                                               | 33-35°C (91-95°F); may be lowered 1.7-2.8°C (3-5°F) each wk for 4-6 wk until weaned                                                                         |
| Colostrum                                                                                            | 15-20 mL in 2-3 feedings within 1 <sup>st</sup> 12 hr of life                                                                                               |
| Iron dextran supplementation                                                                         | 25 mg/animal IM <sup>15</sup> at 1 day of age; may repeat at 3 wk of age <sup>5</sup>                                                                       |
| Other care                                                                                           | Cut umbilical cord and dip in tincture of iodine; trim needle teeth (canines) at 1 day of age                                                               |
| Castration                                                                                           | <3 mo of age                                                                                                                                                |
| Ovariectomy                                                                                          | Not recommended due to high incidence of uterine neoplasia in older sows <sup>19,32</sup>                                                                   |
| Ovariohysterectomy                                                                                   | 3-4 mo of age, but may be performed as early as 6 wk of age                                                                                                 |
| Tusk (canine) removal                                                                                | Not recommended                                                                                                                                             |
| Tusk (canine) trimming                                                                               | As needed                                                                                                                                                   |
| <b>Fecal Examination</b>                                                                             |                                                                                                                                                             |
| Young (6 wk to 6 mo of age)                                                                          | Bimonthly                                                                                                                                                   |
| Adults                                                                                               | Semiannually if potential for exposure                                                                                                                      |

TABLE 11-10 Blood Collection Sites in Miniature Pigs.<sup>27,29,33</sup>

| Venipuncture Site           | Comments                                                                                                                                             |
|-----------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------|
| Cranial vena cava           | Anesthesia required for safety                                                                                                                       |
| Right brachiocephalic vein  | Most pigs will require anesthesia                                                                                                                    |
| Right external jugular vein | Easier if pig is anesthetized                                                                                                                        |
| Cephalic vein               | Thick skin makes this difficult; cut down may be required; good choice for catheterization for fluid or medication administration                    |
| Lateral auricular vein      | Easiest in debilitated or very cooperative pigs; good for obtaining small blood samples; can use for catheterization, but more difficult to maintain |
| Subcutaneous abdominal vein | Easy to visualize and access, even in conscious pigs                                                                                                 |

TABLE 11-11 Recommendations for Feeding Miniature Pigs.<sup>30</sup>

|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <ul style="list-style-type: none"><li>• Miniature pet pigs should be offered feeds made specifically for the miniature pig.</li><li>• A rate of 1-2% of the pig’s body weight daily, depending upon life stage, is usually appropriate.</li><li>• The pig’s current body condition should be the most important consideration when determining how much to feed.</li><li>• Divide daily ration into 2-3 meals daily when possible; ideally broadcast food on a grassy area, or place in food-dispensing toys or in rooting boxes.</li><li>• Some manufacturers of feeds for miniature pigs:</li></ul> |
| Heartland Animal Health, Inc<br><a href="http://www.healthypigs.com">www.healthypigs.com</a><br><br>Mazuri Exotic Animal Feeds<br><a href="http://www.mazuri.com">www.mazuri.com</a><br><br>Ross Mill Farm’s<br><br>Champions Choice                                                                                                                                                                                                                                                                                                                                                                  |

TABLE 11-12 Tips for Oral Dosing of Miniature Pigs.<sup>32</sup>

|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <ul style="list-style-type: none"><li>• Choose pediatric liquid formulations whenever possible.</li><li>• Mix medications with food items, known to be favored by the individual; most pigs prefer sweets, including:</li></ul>                                                                                                                                                                                                                                                                                      |
| <ul style="list-style-type: none"><li>• Jams or jelly, placed on a small piece of bread</li><li>• Fruit flavored gelatin</li><li>• Peanut butter</li><li>• Bread, cookies, pastry, etc.</li><li>• Fruit juice</li></ul>                                                                                                                                                                                                                                                                                              |
| <ul style="list-style-type: none"><li>• If a medication is known to be bitter, a few spoonfuls of peanut butter and jelly smeared on a piece of bread is recommended; if the pig tastes the medication, it will likely refuse this offering on the second dose; be prepared to change the food item for each dose.</li><li>• Small tablets can be placed inside a grape and will be consumed readily by most individuals.</li><li>• Medications can be mixed with sweet fruit juice and frozen into cubes.</li></ul> |

References

1. Almond GW, Stevens JB. Urinalysis techniques for swine practitioners. *Compend Contin Educ Vet.* 1995;17:121–129.
2. Boldrick L. Veterinary Care of Pot-bellied Pet Pigs. Orange, CA: All Publishing Co; 1993:122–123.
3. Braun W, Jr. Reproduction in the potbellied pigs. *Vet Med.* 1993;88:429–434.
4. Braun WF, Jr. Potbellied pigs. general medical care. Bonagura JD, ed. Kirk’s Current Veterinary Therapy XII—Small Animal Practice. Philadelphia: WB

Saunders Co; 1995:1388–1392.

5. Braun WF, Jr., Casteel SW. Potbellied pigs—miniature porcine pets. *Vet Clin North Am Small Anim Pract.* 1993;23:1149–1177.

6. Brockus CW, Mahaffey EA, Bush S, et al. Hematologic and serum biochemical reference intervals for Vietnamese potbellied pigs (*Sus scrofa*). *Comp Clin Path.* 2005;13:162–165.

7. Calle PP, Morris PJ. Anesthesia for nondomestic suids. In: Fowler ME, Miller RE. *Zoo and Wild Animal Medicine: Current Therapy 4*. Philadelphia: WB Saunders Co; 1999:639–646.

8. Claxton-Gill MS, Cornick-Seahorn JL, Gamboa JC, et al. Suspected malignant hyperthermia syndrome in a miniature pot-bellied pig anesthetized with isoflurane. *J Am Vet Med Assoc.* 1993;203:1434–1436.

9. Friendship RM. Antimicrobial drug use in swine. In: Prescott JF, Baggot JD. *Antimicrobial Therapy in Veterinary Medicine*. 4th ed. Ames: Iowa State University Press; 2006:535–543.

10. Heard DJ. Principles and techniques of anesthesia and analgesia for exotic practice. *Vet Clin North Am Small Anim Pract.* 1993;23:1301–1327.

11. Howard JL. Common antimicrobial dosages. In: Howard J, ed. *Current Veterinary Therapy 4—Food Animal Practice*. Philadelphia: WB Saunders Co; 1999:26.

12. Johnson L. Physical and chemical restraint of miniature pet pigs. In: Reeves DE, ed. *Care and Management of Miniature Pet Pigs*. Santa Barbara: Veterinary Practice Publishing Co; 1993:59–66.

13. Kahn CM, ed. *The Merck Veterinary Manual*. 10th ed. Whitehouse Station, NJ: Merck & Co; 2010:1713–1721. 2823

14. Ko JCH, Thurman JC, Tranquilli GJ, et al. Problems encountered when anesthetizing potbellied pigs. *Vet Med.* 1993;88:435–440.

15. Lawhorn B. Personal communication; 2010.
16. Liu J, Fung K, Chen Z, et al. Pharmacokinetics of florfenicol in healthy pigs and in pigs experimentally infected with *Actinobacillus pleuropneumoniae*. *Antimicrob Agents Chemother*. 2003;47:820–823.
17. Longley L. Fancy pigs anaesthesia. In: Longley L, ed. *Anaesthesia of Exotic Pets*. New York: Elsevier; 2008:112–126.
18. Lord LK, Wittum TE, Anderson DE, et al. Resting rectal temperature of Vietnamese potbellied pigs. *J Am Vet Med Assoc*. 1999;215:342–344.
19. Mozzachio K. Personal communication; 2010.
20. Mozzachio K, Tynes VV. Recognition and treatment of pain in the miniature pig. In: Eggers C, Doherty T, eds. *Pain Management in Veterinary Practice*. Ames: Wiley Blackwell; In press.
21. Murison PJ. Delayed dyspnoea in pigs possibly associated with endotracheal intubation. *Vet Anaesth Anal*. 2001;28:226.
22. Padilla LR, Ko JCH. Non-domestic suids. In: West G, Heard D, Caulkett N. *Zoo Animal and Wildlife Immobilization and Anesthesia*. Ames: Blackwell; 2007:567–577.
23. Papich MG. *Saunders Handbook of Veterinary Drugs*, 2nd ed. St. Louis: WB Saunders Co; 2007.
24. Reeves DE. Neonatal care of miniature pigs. In: Reeves DE, ed. *Care and Management of Miniature Pet Pigs*. Santa Barbara: Veterinary Practice Publishing Co; 1993:41–45.
25. Reeves DE. Parasite control in miniature pet pigs. In: Reeves DE, ed. *Care and Management of Miniature Pet Pigs*. Santa Barbara: Veterinary Practice Publishing Co; 1993:101–107.
26. Reeves DE. Vaccination schedule for miniature pigs. In: Reeves DE, ed. *Care and Management of Miniature Pet Pigs*. Santa Barbara: Veterinary Practice

Publishing Co; 1993:109–111.

27. Snook CS. Use of the subcutaneous abdominal vein for blood sampling and intravenous catheterization in potbellied pigs. *J Am Vet Med Assoc*. 2001;219:809–810.
28. Swindle MM. Minipigs as pets. *Proc North Am Vet Conf*; 1993:648–649.
29. Tynes VV. Emergency care for potbellied pigs. *Vet Clin North Am Exotic Anim Pract*. 1998;1:177–189.
30. Tynes VV. Potbellied pig husbandry and nutrition. *Vet Clin North Am Exotic Anim Pract*. 1999;2:193–207.
31. Tynes VV. Vaccinating the pet potbellied pig. *Exotic DVM*. 2000;2.1:11–13.
32. Tynes VV. Personal observation; 2011.
33. Van Metre DC, Angelos SM. Miniature pigs. *Vet Clin North Am Exotic Anim Pract*. 1999;2:519–537.
34. Wertz EM, Wagner AE. Anesthesia in potbellied pigs. *Compend Contin Educ Vet*. 1995;17:369–383.

Chapter 12

Primates

Celia R. Valverde, Marie-Josée Lemoy

TABLE 12-1 Antimicrobial and Antifungal Agents Used in Primates.

| Agent                                           | Dosage                                              | Species/Comments    |
|-------------------------------------------------|-----------------------------------------------------|---------------------|
| Amikacin                                        | 2.3 mg/kg<br>IM<br>q24h <sup>3,65,145</sup>         | Lemurs, chimpanzees |
|                                                 | 5 mg/kg IM<br>q8h <sup>3</sup>                      |                     |
| Amoxicillin                                     | 6.7-13.3<br>mg/kg PO,<br>IM q8h <sup>3,19</sup>     |                     |
|                                                 | 11 mg/kg<br>PO q12h <sup>39</sup>                   |                     |
|                                                 | 11 mg/kg<br>SC, IM<br>q24h <sup>39</sup>            |                     |
|                                                 | 15 mg/kg<br>SC q48h × 3<br>treatments <sup>58</sup> | Macaques/depot form |
|                                                 | 500<br>mg/animal<br>PO, IM, IV <sup>3</sup>         | Chimpanzees         |
| Amoxicillin trihydrate,<br>clavulanic potassium | 6.5-13.5<br>mg/kg PO<br>q8h <sup>19</sup>           | Macaques            |
|                                                 | 13.75 mg/kg<br>PO q12h <sup>3</sup>                 | Chimpanzees         |
|                                                 | 15 mg/kg<br>PO q12h <sup>135</sup>                  |                     |
|                                                 | 62.5 mg PO<br>q12h <sup>101</sup>                   | Lemurs              |
| Amphotericin B                                  | 0.25-1<br>mg/kg IV<br>q24h <sup>67</sup>            |                     |
|                                                 |                                                     |                     |



|                  |                                                                                                  |                                           |
|------------------|--------------------------------------------------------------------------------------------------|-------------------------------------------|
| Ampicillin       | 20 mg/kg<br>PO, IM, IV<br>q8h <sup><a href="#">3,67</a></sup>                                    | Chimpanzees                               |
|                  | 25-50<br>mg/kg/day<br>IM, IV<br>divided q6-<br>8h <sup><a href="#">3,19</a></sup>                |                                           |
|                  | 50-100<br>mg/kg IM<br>q12h × 7-10<br>days <sup><a href="#">65</a></sup>                          |                                           |
| Azithromycin     | 5-10 mg/kg<br>PO q24h <sup><a href="#">3</a></sup>                                               | Chimpanzees                               |
|                  | 20 mg/kg<br>PO q24h <sup><a href="#">77</a></sup>                                                | Macaques/ <i>Lawsonia intracellularis</i> |
|                  | 25-50<br>mg/kg SC<br>q24h × 7<br>days <sup><a href="#">112</a></sup>                             | Macaques/antimalarial                     |
|                  | 40 mg/kg<br>SC, IM<br>once, then<br>20 mg/kg<br>q24h × 2-5<br>days <sup><a href="#">19</a></sup> |                                           |
| Cefazolin sodium | 25 mg/kg<br>IM, IV q12h<br>× 7-10<br>days <sup><a href="#">19,65</a></sup>                       | Macaques, chimpanzees                     |
| Cefotaxime       | 50 mg/kg<br>IM, IV<br>q8h <sup><a href="#">18</a></sup>                                          |                                           |
|                  | 100-200<br>mg/kg IV<br>q6-8h <sup><a href="#">107</a></sup>                                      |                                           |
|                  | 1 g/animal<br>IM, IV q6-<br>12h <sup><a href="#">3</a></sup>                                     | Chimpanzees                               |
| Ceftazidime      | 50 mg/kg<br>IM, IV<br>q8h <sup><a href="#">29</a></sup>                                          | Lemurs                                    |
|                  |                                                                                                  |                                           |

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| Ceftizoxime (Cefizox, Fujisawa)  | 75-100 mg/kg IM q12h × 7 days <sup>65</sup>  |                                                                                                                                     |
| Ceftriaxone                      | 10 mg/kg IV <sup>131</sup>                   | Macaques, chimpanzees/PD                                                                                                            |
|                                  | 50 mg/kg IM q24h <sup>3,19</sup>             | Macaques                                                                                                                            |
|                                  | 50-100 mg/kg IM, IV q12-24h <sup>107</sup>   | Great apes/bacterial meningitis; excellent penetration into cerebrospinal fluid; transient, self-limiting diarrhea is a side effect |
| Cephalexin                       | 20 mg/kg PO q12h <sup>32</sup>               |                                                                                                                                     |
|                                  | 30 mg/kg PO q12h <sup>3,19</sup>             |                                                                                                                                     |
| Cephaloridine                    | 20 mg/kg IM q12h <sup>32</sup>               |                                                                                                                                     |
| Cephalothin                      | 25 mg/kg IM q12h <sup>121</sup>              |                                                                                                                                     |
| Chloramphenicol palmitate        | 25 mg/kg PO q8h <sup>3</sup>                 | Infants                                                                                                                             |
|                                  | 50 mg/kg PO q12h <sup>32</sup>               |                                                                                                                                     |
| Chloramphenicol sodium succinate | 20 mg/kg IM q12h <sup>3,39</sup>             |                                                                                                                                     |
|                                  | 33 mg/kg IM q8h <sup>3</sup>                 |                                                                                                                                     |
|                                  | 50-100 mg/kg SC, IM, IV q8h <sup>51,67</sup> |                                                                                                                                     |
|                                  | 110 mg/kg IM q6h × 5-10 days <sup>51</sup>   | Pneumococcal meningoen-ceph-alitis                                                                                                  |
| Ciprofloxacin                    | 10 mg/kg PO q12h <sup>3,19</sup>             |                                                                                                                                     |
|                                  | 10-25 mg/kg PO q12h <sup>58</sup>            |                                                                                                                                     |
|                                  | 16-20                                        |                                                                                                                                     |

|                |                                                                |                                                                                                                                               |
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|                | mg/kg PO q12h <sup>65</sup>                                    | Macaques/based on PD dosage below; <sup>75</sup> suspension of crushed tablets in water                                                       |
|                | 250 mg/animal PO once, then 125 mg q12h <sup>75</sup>          | Macaques/PD (5.1-13 kg animals)                                                                                                               |
| Clarithromycin | 10 mg/kg PO q12h × 7 days <sup>25</sup>                        |                                                                                                                                               |
|                | 10 mg/kg PO q12h × 10 days <sup>25</sup>                       | Macaques/treatment of <i>Helicobacter pylori</i> infection; part of quadruple therapy with omeprazole, amoxicillin, and bismuth subsalicylate |
|                | 20 mg/kg PO q24h <sup>5</sup>                                  | Macaques/PD                                                                                                                                   |
|                | 250-500 mg/animal PO q12h <sup>3</sup>                         | Chimpanzees                                                                                                                                   |
| Clindamycin    | 10 mg/kg PO q12h <sup>135</sup>                                |                                                                                                                                               |
|                | 12.5 mg/kg IM q8h <sup>32</sup>                                |                                                                                                                                               |
|                | 150-300 mg/animal PO q6h <sup>3</sup>                          | Chimpanzees                                                                                                                                   |
|                | 300-600 mg/animal IM q8-12h <sup>3</sup>                       | Chimpanzees                                                                                                                                   |
| Doxycycline    | 2.5 mg/kg PO q12h × 1 day, then 2.5 mg/kg PO q24h <sup>3</sup> |                                                                                                                                               |
|                | 3-4 mg/kg PO q12h <sup>65</sup>                                | Macaques/based on PD dosage below <sup>75</sup>                                                                                               |
|                | 5 mg/kg PO q12h <sup>19</sup>                                  |                                                                                                                                               |
|                | 60 mg/animal PO once, then 30 mg/animal                        | Macaques/PD (5.1-13 kg animals)                                                                                                               |

|                                                                           |                                                                           |                                                                                                                                                                                                                                                                                                       |
|---------------------------------------------------------------------------|---------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                                                                           | q12h <sup>75</sup>                                                        |                                                                                                                                                                                                                                                                                                       |
| Enrofloxacin (Baytril, Bayer)                                             | 5 mg/kg PO, IM q24h × 10 days <sup>6,33,53</sup>                          | Most species/ <i>Shigella flexneri</i> ; injectable form given PO                                                                                                                                                                                                                                     |
|                                                                           | 5 mg/kg nasogastric or orogastric intubation q24h × 10 days <sup>85</sup> | Macaques/PD; <i>Shigella</i> gastroenteritis                                                                                                                                                                                                                                                          |
|                                                                           | 5 mg/kg PO, IM q12-24h <sup>3</sup>                                       |                                                                                                                                                                                                                                                                                                       |
| Erythromycin                                                              | 35 mg/kg PO q8h <sup>3</sup>                                              |                                                                                                                                                                                                                                                                                                       |
|                                                                           | 40 mg/kg PO, IM q8-12h <sup>18</sup>                                      |                                                                                                                                                                                                                                                                                                       |
|                                                                           | 75 mg/kg PO q12h × 10 days <sup>65</sup>                                  | Most species/ <i>Campylobacter</i> -associated diarrhea                                                                                                                                                                                                                                               |
| Erythromycin ethyl-succinate (pediatric suspension; EryPed Drops, Abbott) | 20 mg/kg PO q12h <sup>116</sup>                                           | Tamarins/clostridial enteritis                                                                                                                                                                                                                                                                        |
| Ethambutol                                                                | 22.5 mg/kg PO q24h <sup>146</sup>                                         | Macaques/mycobacteriosis; treat concurrently with isoniazid and rifampin; reduce to 15 mg/kg after 6 wk; continue treatment for 1 yr; treatment of tuberculosis in non-human primates is controversial due to the inability to eliminate carrier state and potential of drug resistance <sup>73</sup> |
| Fluconazole                                                               | 2-3 mg/kg PO q24h × 30 days <sup>47</sup>                                 | Macaques/coccidioidomycosis; prolonged treatment is necessary; relapses may occur                                                                                                                                                                                                                     |
|                                                                           | 18 mg/kg PO q24h <sup>8</sup>                                             | Swamp monkeys/systemic mycoses; treat concurrently with flucytosine; may be effective as a sole agent                                                                                                                                                                                                 |
| Flucytosine (Ancobon, Roche)                                              | 50-150 mg/kg/day PO divided q6h <sup>3</sup>                              | Chimpanzees                                                                                                                                                                                                                                                                                           |
|                                                                           | 143 mg/kg                                                                 | Swamp monkeys/systemic mycoses; treat concurrently                                                                                                                                                                                                                                                    |

|              |                                                      |                                                                |
|--------------|------------------------------------------------------|----------------------------------------------------------------|
|              | PO q24h <sup>8</sup>                                 | with fluconazole                                               |
| Furazolidone | 5 mg/kg PO<br>q6h × 7<br>days <sup>65</sup>          |                                                                |
|              | 10 mg/kg<br>PO q12h <sup>3</sup>                     |                                                                |
|              | 10-15<br>mg/kg PO<br>q24h <sup>95</sup>              |                                                                |
|              | 20-40<br>mg/kg PO<br>q6h <sup>67</sup>               |                                                                |
|              | 100<br>mg/animal<br>PO q6h <sup>3</sup>              | Chimpanzees                                                    |
| Gentamicin   | 1-2 mg/kg<br>IM, IV q8h<br>× 5-7 days <sup>65</sup>  |                                                                |
|              | 2-3 mg/kg<br>IM, IV q12h<br>× 5-7 days <sup>65</sup> |                                                                |
|              | 2-4 mg/kg<br>IM q12h <sup>3</sup>                    |                                                                |
|              | 3 mg/kg IM<br>q6-8h <sup>140</sup>                   | Baboons/PD                                                     |
| Griseofulvin | 20 mg/kg<br>PO q24h <sup>67</sup>                    |                                                                |
|              | 200 mg/kg<br>PO once<br>q10d <sup>67</sup>           |                                                                |
|              | 500 mg/day<br>PO divided<br>q6-24h <sup>3</sup>      | Chimpanzees                                                    |
| Imipenem     | 10 mg/kg<br>IV <sup>131</sup>                        | Macaques, chimpanzees/PD                                       |
|              | 25 mg/kg<br>IV q12h <sup>36</sup>                    | Infuse over 30 min                                             |
|              | 500-1000<br>mg IM, IV<br>q8h <sup>132</sup>          | Chimpanzees/methicillin resistant <i>Staphylococcus aureus</i> |
| Isoniazid    | 5 mg/kg PO                                           |                                                                |

|                    |                                                                     |                                                                                                                                                                                                                                                                                                                                                                                                   |
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|                    | q24h <sup>3</sup>                                                   | Macaques/mycobacteriosis; treat concurrently with ethambutol and rifampin; reduce to 10 mg/kg after 6 wk; continue treatment for 1 yr; supplement with pyridoxine; prophylactic use of isoniazid is controversial; treatment may mask infection and prevent detection by tuberculin skin testing; isoniazid has been associated with false negative tuberculin skin testing results <sup>73</sup> |
|                    | 15 mg/kg<br>PO q24h <sup>146</sup>                                  |                                                                                                                                                                                                                                                                                                                                                                                                   |
|                    | 30-50<br>mg/kg PO<br>q24h <sup>3</sup>                              | Chimpanzees/active TB test for 9 mo; prophylaxis: 300 mg/day PO                                                                                                                                                                                                                                                                                                                                   |
| Itraconazole       | 10 mg/kg<br>PO q24h                                                 | Fungal (yeast) gastroenteritis                                                                                                                                                                                                                                                                                                                                                                    |
| Kanamycin          | 7.5 mg/kg<br>IM q12h <sup>67</sup>                                  |                                                                                                                                                                                                                                                                                                                                                                                                   |
| Ketoconazole       | 5-10 mg/kg<br>PO q12h <sup>3,18</sup>                               | Candidiasis                                                                                                                                                                                                                                                                                                                                                                                       |
|                    | 200-400<br>mg/day PO <sup>3</sup>                                   | Chimpanzees                                                                                                                                                                                                                                                                                                                                                                                       |
| Lincomycin         | 5-10 mg/kg<br>IM q12h <sup>65</sup>                                 |                                                                                                                                                                                                                                                                                                                                                                                                   |
| Methicillin sodium | 50 mg/kg<br>IM q12h × 7<br>days <sup>51</sup>                       |                                                                                                                                                                                                                                                                                                                                                                                                   |
| Metronidazole      | 12.5-15<br>mg/kg PO<br>q12h <sup>64</sup>                           | <i>Clostridium</i> ; used in conjunction with tylosin                                                                                                                                                                                                                                                                                                                                             |
|                    | 25 mg/kg<br>PO q12h <sup>99</sup>                                   | Colobinae/gastroenteritis                                                                                                                                                                                                                                                                                                                                                                         |
|                    | 50 mg/kg<br>PO or via<br>orogastric<br>tubing<br>q24h <sup>18</sup> | Macaques/gastroenteritis; inflammatory bowel disease                                                                                                                                                                                                                                                                                                                                              |
| Minocycline        | 2 mg/kg PO<br>q12h <sup>70</sup>                                    | Prosimians                                                                                                                                                                                                                                                                                                                                                                                        |
|                    | 15 mg/kg<br>PO q12h × 7<br>days <sup>65,72</sup>                    | Lemurs <sup>72</sup>                                                                                                                                                                                                                                                                                                                                                                              |
| Neomycin           | 10 mg/kg<br>PO q12h <sup>32</sup>                                   |                                                                                                                                                                                                                                                                                                                                                                                                   |

|                                |                                                                                    |                                                                         |
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|                                | 50 mg/kg<br>PO q12h <sup><a href="#">3</a></sup>                                   |                                                                         |
| Nitrofurantoin                 | 2-4 mg/kg<br>IM, IV<br>q8h <sup><a href="#">67</a></sup>                           |                                                                         |
| Nitrofurazone                  | 11 mg/kg<br>PO q24h <sup><a href="#">51</a></sup>                                  |                                                                         |
| Norfloxacin (Noroxin, Roberts) | 25 mg/kg<br>via<br>nasogastric<br>intubation<br>q12h <sup><a href="#">43</a></sup> | Macaques/PD                                                             |
|                                | 25-30<br>mg/kg PO<br>q12h <sup><a href="#">116</a></sup>                           | Tamarins                                                                |
| Nystatin                       | 100,000<br>U/animal<br>PO q8h <sup><a href="#">3,19</a></sup>                      |                                                                         |
|                                | 200,000<br>U/animal<br>PO q6h <sup><a href="#">39</a></sup>                        | Gastrointestinal candidiasis; continue 48 hr after<br>clinical recovery |
|                                | 500,000 -<br>1,000,000<br>U/animal<br>PO q8h <sup><a href="#">3</a></sup>          | Chimpanzees                                                             |
| Oxacillin                      | 16.5 mg/kg<br>SC, IM<br>q8h <sup><a href="#">18</a></sup>                          |                                                                         |
| Oxytetracycline                | 10 mg/kg<br>SC, IM<br>q24h <sup><a href="#">32,135</a></sup>                       |                                                                         |
|                                | 250-300<br>mg/day PO,<br>IM divided<br>q8-24h <sup><a href="#">3</a></sup>         | Chimpanzees                                                             |
| Penicillin G, benzathine       | 20,000-<br>60,000 U/kg<br>SC, IM<br>q24h <sup><a href="#">18</a></sup>             |                                                                         |
|                                | 40,000 U/kg<br>IM q72h <sup><a href="#">67</a></sup>                               |                                                                         |
|                                | 20,000 U/kg                                                                        |                                                                         |

|                        |                                                                               |                                                                                                                                                                                                                                                               |
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| Penicillin G, procaine | IM q12h <sup>67</sup>                                                         |                                                                                                                                                                                                                                                               |
|                        | 20,000-40,000 U/kg<br>SC, IM<br>q12h <sup>18</sup>                            | Macaques, squirrel monkeys                                                                                                                                                                                                                                    |
|                        | 22,000 U/kg<br>IM q24h <sup>3</sup>                                           | Chimpanzees                                                                                                                                                                                                                                                   |
|                        | 50,000-60,000 U/kg<br>SC, IM<br>q24h <sup>101</sup>                           | Lemurs                                                                                                                                                                                                                                                        |
| Piperacillin sodium    | 80-100 mg/kg IM,<br>IV q8h × 7-10 days <sup>65</sup>                          |                                                                                                                                                                                                                                                               |
|                        | 100-150 mg/kg IM,<br>IV q12h <sup>65</sup>                                    |                                                                                                                                                                                                                                                               |
| Rifampin               | 22.5 mg/kg<br>PO q24h <sup>146</sup>                                          | Macaques/mycobacteriosis; treat concurrently with ethambutol and isoniazid; reduce to 15 mg/kg after 6 wk; continue treatment for 1 yr; controversial because of the public health danger and the induction of potential drug resistant strains <sup>73</sup> |
|                        | 600 mg PO,<br>IV q24h <sup>3</sup>                                            | Chimpanzees                                                                                                                                                                                                                                                   |
| Sulfamethazine         | 66 mg/kg<br>PO q12h <sup>20</sup>                                             |                                                                                                                                                                                                                                                               |
| Sulfasalazine          | —                                                                             | Gastrointestinal antibacterial and antiinflammatory properties                                                                                                                                                                                                |
|                        | 20 mg/kg<br>PO q24h × 28 days,<br>then 40 mg/kg PO<br>q24h prn <sup>102</sup> | Western lowland gorillas/reactive arthritis                                                                                                                                                                                                                   |
|                        | 30 mg/kg<br>PO q12h <sup>61</sup>                                             | Spider monkeys                                                                                                                                                                                                                                                |
|                        | 50 mg/kg<br>PO q24h × 10 wk <sup>91</sup>                                     | Cotton-top tamarins/chronic colitis                                                                                                                                                                                                                           |
| Sulfisoxazole          | 50 mg/kg<br>PO q24h <sup>58</sup>                                             | Macaques                                                                                                                                                                                                                                                      |



|                               |                                                                                         |                                                             |
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| Tetracycline                  | 20-25<br>mg/kg PO<br>q8-12h × 7-<br>10 days <sup><a href="#">3,65</a></sup>             | Most species                                                |
|                               | 25 mg/kg<br>IM, IV<br>q12h <sup><a href="#">65</a></sup>                                |                                                             |
| Trimethoprim/sulfa            | 24 mg/kg<br>PO q12h <sup><a href="#">39</a></sup>                                       |                                                             |
|                               | 25 mg/kg<br>SC, IM<br>q24h <sup><a href="#">29</a></sup>                                | Lemurs                                                      |
|                               | 27 mg/kg<br>SC q24h <sup><a href="#">39</a></sup>                                       |                                                             |
|                               | 50 mg/kg<br>PO q12h <sup><a href="#">29</a></sup>                                       | Lemurs                                                      |
| Trimethoprim/sulfadiazine     | 15 mg/kg<br>PO q12h <sup><a href="#">135</a></sup>                                      |                                                             |
|                               | 24-48<br>mg/kg SC <sup><a href="#">51</a></sup>                                         |                                                             |
|                               | 30 mg/kg<br>SC q24h <sup><a href="#">135</a></sup>                                      |                                                             |
| Trimethoprim/sulfamethoxazole | 15 mg/kg<br>PO, IM<br>q12h, or 30<br>mg/kg PO,<br>IM q24h <sup><a href="#">70</a></sup> | Prosimians                                                  |
|                               | 50 mg/kg<br>PO q24h <sup><a href="#">29</a></sup>                                       | Lemurs                                                      |
|                               | 4 mg/kg PO,<br>SC q8h <sup><a href="#">3,19</a></sup>                                   | Based on trimethoprim                                       |
|                               | 800<br>mg/animal<br>PO q12h <sup><a href="#">3</a></sup>                                | Chimpanzee/based on sulfamethoxazole                        |
| Tylosin (Tylan, Elanco)       | 5 mg/kg PO<br>q12h <sup><a href="#">64</a></sup>                                        | <i>Clostridium</i> ; used in conjunction with metronidazole |
|                               | 10 mg/kg<br>IM q12h <sup><a href="#">51</a></sup>                                       |                                                             |
|                               | 20 mg/kg<br>IM<br>q24h <sup><a href="#">13,19</a></sup>                                 | Macaque/chronic diarrhea <sup><a href="#">13</a></sup>      |

|            |                                                               |             |
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| Vancomycin | 20 mg/kg<br>IM, IV<br>q12h <sup>18</sup>                      |             |
|            | 40<br>mg/kg/day<br>IV<br>continuous<br>infusion <sup>36</sup> |             |
|            | 500<br>mg/animal<br>PO q6h <sup>3</sup>                       | Chimpanzees |

TABLE 12-2 Antiparasitic Agents Used in Primates.

| Agent                        | Dosage                                                                                                 | Species/Comments                                                                                                                                                              |
|------------------------------|--------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Albendazole                  | 10 mg/kg PO <sup>70</sup>                                                                              | Prosimians/nematodes                                                                                                                                                          |
|                              | 10 mg/kg PO q12h <sup>148</sup>                                                                        | Macaques                                                                                                                                                                      |
|                              | 25 mg/kg PO q12h × 5 days <sup>147</sup>                                                               | <i>Filaroides</i>                                                                                                                                                             |
|                              | 28.5 mg/animal PO q12h × 10 days × 3 treatments with a 10-day interval <sup>150</sup>                  | Red ruffed lemurs/subcutaneous cysticercosis; also administer praziquantel 23 mg/animal PO q10d × 3 treatments                                                                |
| Amitraz                      | 250 ppm dip for 2-5 min duration × 4 treatments q14d or until resolution of skin lesions <sup>63</sup> | Tamarins/demodectic mange; no haircoat clipping or bathing was performed; animals were not rinsed after treatment; dried with a hot-air dryer; ataxia (transient) may develop |
| Azithromycin                 | 25-50 mg/kg SC q24h <sup>112</sup>                                                                     | Macaques/antimalarial                                                                                                                                                         |
|                              | 40 mg/kg IM q24h first day; 20 mg/kg days 2-5 <sup>18</sup>                                            | <i>Cyptosporidium parvum</i> ; limited effectiveness                                                                                                                          |
| Chloroquine (Aralen, Sanofi) | 10 mg/kg PO, IM once, then 5 mg/kg 6 hr later, then 5 mg/kg q24h × 2 days <sup>147</sup>               | Malaria ( <i>Plasmodium</i> sp); treat concurrently with primaquine                                                                                                           |
| Dichlorvos                   | 10-15 mg/kg PO q24h × 2-3 days <sup>54</sup>                                                           | Gastrointestinal nematodes                                                                                                                                                    |
| Diethylcarbamazine           | 6-20 mg/kg PO q24h × 6-15 days <sup>134,147</sup>                                                      | Owl monkeys/filariasis (i.e., <i>Dipetalonema</i> )                                                                                                                           |

|                                                         |                                                        |                                                                                                                                                  |
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|                                                         | 20-40 mg/kg PO q24h × 7-21 days <sup>65</sup>          |                                                                                                                                                  |
|                                                         | 50 mg/kg PO q24h × 10 days <sup>26</sup>               | Squirrel monkeys/filariasis; effective against microfilaria and adults; monkeys were microfilaria negative for 12-24 wk after treatment          |
| Doxycycline                                             | 5 mg/kg PO once, then 2.5 mg/kg PO q24h <sup>147</sup> | <i>Balantidium</i>                                                                                                                               |
| Fenbendazole                                            | 50 mg/kg PO q24h × 3 days <sup>3,29</sup>              | Chimpanzees, lemurs                                                                                                                              |
|                                                         | 50 mg/kg PO q24h × 14 days <sup>147</sup>              | <i>Filaroides</i>                                                                                                                                |
| Furazolidone                                            | —                                                      | Great apes/ <i>Giardia</i> ; more palatable, but less effective than other agents                                                                |
|                                                         | 5 mg/kg PO q6h × 7 days <sup>133</sup>                 | Great apes (juveniles)                                                                                                                           |
|                                                         | 100 mg/animal PO q6h × 7 days <sup>133</sup>           | Great apes (adults)                                                                                                                              |
| Iodoquinol (diiodohydroxyquinoline) (Yodoxin, Glenwood) | —                                                      | Great apes/minimal absorption; use with other agents for invasive disease; 14-21 days for <i>Balantidium coli</i> ; 21 days for <i>Entamoeba</i> |
|                                                         | 12-16 mg/kg PO q8h <sup>133</sup>                      | Great apes (infants, juveniles)                                                                                                                  |
|                                                         | 20 mg/kg PO q12h × 21 days <sup>67</sup>               | Intestinal amebiasis; <i>Balantidium</i> ; for treatment of cystic form, use in combination with metronidazole <sup>18</sup>                     |
|                                                         | 30-40 mg/kg PO q24h × 3-21 days <sup>87</sup>          | Great apes                                                                                                                                       |
|                                                         | 35-50 mg/kg PO q24h × 21 days <sup>133</sup>           | Great apes (juveniles)                                                                                                                           |
|                                                         | 630 mg/animal PO q8h × 20 days <sup>3</sup>            | Chimpanzees                                                                                                                                      |
| Ivermectin                                              | 0.2 mg/kg PO, SC, IM <sup>10,29,65,147</sup>           | May repeat in 10-14 days                                                                                                                         |
|                                                         | 0.3 mg/kg PO q7d × 4 treatments <sup>66</sup>          | Callitrichids/ <i>Gongylonema</i> sp                                                                                                             |
| Levamisole                                              | 2.5 mg/kg PO q24h × 14 days <sup>69</sup>              | Prosimians/ <i>Physaloptera</i>                                                                                                                  |
|                                                         | 4-5 mg/kg PO q24h × 6 days <sup>98</sup>               | Saki monkeys/oral spiruridiasis                                                                                                                  |
|                                                         | 5 mg/kg PO, repeat in                                  |                                                                                                                                                  |

|                       |                                                               |                                                                                                                             |
|-----------------------|---------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------|
|                       | 21 days <sup>54</sup>                                         |                                                                                                                             |
|                       | 7.5 mg/kg SC, repeat in 14 days <sup>51</sup>                 |                                                                                                                             |
|                       | 10 mg/kg PO <sup>147</sup>                                    | <i>Strongyloides, Filaroides, Trichuris</i>                                                                                 |
| Mebendazole           | 10-20 mg/kg PO q12h × 3 days, repeat in 14 days <sup>69</sup> | Prosimians/gastrointestinal nematodes                                                                                       |
|                       | 15 mg/kg PO q24h × 3 days <sup>147</sup>                      | <i>Strongyloides, Necator, Pterygodermatitis, Trichuris</i>                                                                 |
|                       | 22 mg/kg PO q24h × 3 days, repeat in 14 days <sup>39</sup>    |                                                                                                                             |
|                       | 50 mg/kg PO q12h × 3 days <sup>3</sup>                        |                                                                                                                             |
|                       | 70 mg/kg PO q24h × 3 days <sup>98</sup>                       | New World primates/oral spiruridiasis; use treatment periodically                                                           |
|                       | 100 mg/kg PO q24h for alternating wk <sup>98</sup>            | Callitrichids/prevention of mortality by acanthocephalan; surgical excision of worms in the intestinal tract is recommended |
|                       | 100 mg/kg PO q12h × 3 days <sup>3</sup>                       | Monkeys/ <i>Trichuris</i>                                                                                                   |
|                       | 100 mg/animal PO q12h × 3 days <sup>3</sup>                   | Chimpanzees                                                                                                                 |
| Mefloquine            | 25 mg/kg PO once <sup>18</sup>                                | Antimalarial                                                                                                                |
| Metronidazole         | 17.5-25 mg/kg PO q12h × 10 days <sup>147</sup>                | Enteric flagellates and amoebas                                                                                             |
|                       | 30-50 mg/kg PO q12h × 5-10 days <sup>93,147</sup>             | <i>Balantidium coli</i>                                                                                                     |
|                       | 35 mg/kg PO q24h <sup>104</sup>                               | Macaques/ <i>Trichomonas vaginalis</i>                                                                                      |
| Neoarsphenamine       | 20 mg/kg IP q5d <sup>96</sup>                                 | Squirrel monkeys/hemobartonellosis; arsenic compound dissolved and diluted in sterile distilled water (0.5 mL/dose)         |
| Niclosamine           | 150 mg/kg once <sup>134</sup>                                 | Owl monkeys/intestinal cestodiasis                                                                                          |
|                       | 166 mg/kg <sup>147</sup>                                      | New World primates/cestodes, anoplocephalids                                                                                |
| Oxibendazole          | 10 mg/kg PO q24h <sup>66</sup>                                | Squirrel monkeys/ <i>Encephalitozoon cuniculi</i>                                                                           |
| Oxytetracycline       | 1500 mg/animal q24h IV, continuous infusion <sup>133</sup>    | Gorillas/ <i>Balantidium coli</i> ; nonambulatory animals                                                                   |
| Paromomycin (Humatin, | 10 mg/kg PO q8h × 5-                                          | Great apes/ <i>Entamoeba</i>                                                                                                |

|                                                 |                                                                                   |                                                                                                                                                                                                 |
|-------------------------------------------------|-----------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Park Davis)                                     | 10 days <sup>133</sup><br>10-20 mg/kg PO q12h ×<br>5-10 days <sup>93</sup>        | <i>Balantidium coli</i>                                                                                                                                                                         |
|                                                 | 12.5-15 mg/kg PO q12h<br>× 5-10 days <sup>147</sup>                               | New World primates/amoebae; minimal<br>absorption; use with other agents for invasive<br>disease                                                                                                |
|                                                 | 25-30 mg/kg q12h × 5-<br>10 days <sup>134</sup>                                   | Owl monkeys/enteric amoebas                                                                                                                                                                     |
|                                                 | 100 mg/kg q24h × 10<br>days <sup>46</sup>                                         | Cercopithecids, pongids/antiprotozoan activity of<br>the drug seems to be related to the protozoal<br>species and the host species                                                              |
| Pentamidine isethionate<br>(NebuPent, Fujisawa) | 4 mg/kg IM, IV q24h ×<br>14 days <sup>133</sup>                                   | Great apes/ <i>Pneumocystis</i> ; slow IV infusion; may<br>cause hypotension, cardiac arrhythmias                                                                                               |
| Piperazine                                      | 65 mg/kg PO q24h × 10<br>days <sup>54</sup>                                       |                                                                                                                                                                                                 |
| Praziquantel (Droncit,<br>Bayer)                | 5 mg/kg PO, IM, SC<br>once <sup>3,19</sup>                                        |                                                                                                                                                                                                 |
|                                                 | 15-20 mg/kg PO, IM <sup>147</sup>                                                 | Some cestodes                                                                                                                                                                                   |
|                                                 | 20 mg/kg PO q8h × 3<br>treatments <sup>3</sup>                                    | Chimpanzees                                                                                                                                                                                     |
|                                                 | 23 mg/animal PO q10d<br>× 3 treatments <sup>150</sup>                             | Red ruffed lemurs/subcutaneous cysticercosis;<br>administer with albendazole 28.5 mg/animal PO<br>q12h × 10 days × 3 treatments with a 10-day<br>interval                                       |
|                                                 | 40 mg/kg PO, IM <sup>147</sup>                                                    | Trematodes                                                                                                                                                                                      |
| Primaquine                                      | 0.3 mg/kg PO q24h ×<br>14 days <sup>147</sup>                                     | <i>Plasmodium</i> ; treat concurrently with chloroquine                                                                                                                                         |
| Pyrantel pamoate                                | 5-10 mg/kg PO × 3<br>days <sup>70</sup>                                           | Prosimians/nematodes                                                                                                                                                                            |
|                                                 | 6 mg/kg PO <sup>29</sup>                                                          | Lemurs                                                                                                                                                                                          |
|                                                 | 10 mg/kg PO, repeat in<br>3 wk <sup>3</sup>                                       | Chimpanzees                                                                                                                                                                                     |
|                                                 | 11 mg/kg PO, once <sup>147</sup>                                                  | <i>Necator</i> ; pinworms                                                                                                                                                                       |
|                                                 | 11 mg/kg PO, repeat in<br>14 days <sup>10</sup>                                   | Owl monkeys                                                                                                                                                                                     |
| Pyrimethamine<br>(Daraprim, Glaxo<br>Wellcome)  | 2 mg/kg PO q24h × 3<br>days, then 1 mg/kg PO<br>q24h × 28 days <sup>133,147</sup> | Great apes/ <i>Toxoplasma</i> ; maximum dosages of<br>100 mg/animal q24h for days 1-3 and 25<br>mg/animal q24h for 28 days; treat concurrently<br>with sulfadiazine; supplement with folic acid |
|                                                 | 10 mg/kg q24h <sup>112</sup>                                                      | <i>Plasmodium</i> ; folic acid antagonist; monitor for<br>signs of folic acid deficiency                                                                                                        |

|                                 |                                                                 |                                                           |
|---------------------------------|-----------------------------------------------------------------|-----------------------------------------------------------|
| Quinacrine (Atabrine, Winthrop) | 2 mg/kg PO q8h × 7 days <sup>133</sup>                          | Great apes/ <i>Giardia</i> ; maximum dose of 300 mg/day   |
| Ronnel (Ectoral, Mallinckrodt)  | 55 mg/kg PO q48h × 4 treatments, then q7d × 3 mo <sup>147</sup> | Lung mites                                                |
|                                 | Topically <sup>147</sup>                                        | Ectoparasitic mites                                       |
| Sulfadiazine                    | —                                                               | <i>Toxoplasma</i> ; treat concurrently with pyrimethamine |
|                                 | 25-50 mg/kg PO q6h <sup>133</sup>                               | Great apes/maximum dose of 6 g/animal/treatment           |
|                                 | 100 mg/kg PO q24h <sup>147</sup>                                |                                                           |
| Sulfadimethoxine                | 50 mg/kg PO once, then 25 mg/kg q24h <sup>147</sup>             | Coccidiosis                                               |
| Tetracycline                    | 15 mg/kg PO q8h × 10-14 days <sup>133</sup>                     | Great apes (infants, juveniles)/ <i>Balantidium coli</i>  |
|                                 | 25-50 mg/kg PO q24h × 5-10 days <sup>87</sup>                   | Great apes/ <i>Entamoeba</i> , <i>Balantidium</i>         |
|                                 | 500-1000 mg/animal PO q8h × 10-14 days <sup>133</sup>           | Great apes (adults)/ <i>Balantidium coli</i>              |
| Thiabendazole                   | 50 mg/kg PO q24h × 2 days <sup>147</sup>                        | <i>Strongyloides</i> , <i>Necator</i>                     |
|                                 | 75-100 mg/kg PO, repeat in 21 days <sup>54</sup>                |                                                           |
|                                 | 100 mg/kg PO once, repeat in 14 days <sup>10</sup>              | Owl monkeys                                               |
| Trimethoprim/sulfa              | 30 mg/kg PO q6h × 14 days <sup>133</sup>                        | Great apes/ <i>Pneumocystis carinii</i>                   |

TABLE 12-3 Chemical Restraint/Anesthetic/Analgesic Agents Used in Primates.

| Agent                                                               | Dosage                                    | Species/Comments                                        |
|---------------------------------------------------------------------|-------------------------------------------|---------------------------------------------------------|
| Acepromazine                                                        | —                                         | See butorphanol and ketamine for combinations           |
|                                                                     | 0.1-0.5 mg/kg PO, SC, IM, IV <sup>3</sup> | Chimpanzees (adults)                                    |
|                                                                     | 0.2 mg/kg IM <sup>34</sup>                | Moderate sedation; no immobilization                    |
| Acetaminophen (Children’s Tylenol Grape Suspension, McNeil Consumer | 5-10 mg/kg PO q6h <sup>67</sup>           | Macaques, New World primates <sup>111</sup> /analgesic; |

|                                 |                                                                                                                                                           |                                                                                                                                                                                                                                                                                            |
|---------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Products)                       |                                                                                                                                                           | antipyretic                                                                                                                                                                                                                                                                                |
|                                 | 15-20 mg/kg rectal suppository <sup><a href="#">111</a></sup>                                                                                             |                                                                                                                                                                                                                                                                                            |
|                                 | 500-1000 mg/animal PO q8h <sup><a href="#">3</a></sup>                                                                                                    | Chimpanzees (adults)                                                                                                                                                                                                                                                                       |
| Acetylsalicylic acid (aspirin)  | —                                                                                                                                                         | Analgesic; antiinflammatory; antipyretic                                                                                                                                                                                                                                                   |
|                                 | 5-10 mg/kg PO q4-6h <sup><a href="#">3,52</a></sup>                                                                                                       | Monkeys, chimpanzees                                                                                                                                                                                                                                                                       |
|                                 | 25 mg/kg rectal suppository <sup><a href="#">109</a></sup>                                                                                                |                                                                                                                                                                                                                                                                                            |
| Alphaxalone/alphadolone         | —                                                                                                                                                         | Injectable steroid anesthetic; not available in the United States <sup><a href="#">111</a></sup>                                                                                                                                                                                           |
|                                 | 10-12 mg/kg IV <sup><a href="#">34</a></sup>                                                                                                              | Short surgical anesthesia (5-10 min) <sup><a href="#">34</a></sup>                                                                                                                                                                                                                         |
|                                 | 10-12 mg/kg IV, <sup><a href="#">37</a></sup> constant rate infusion of 0.2 mg/kg/min; or 4 mg/kg/20 min intermittent bolus <sup><a href="#">24</a></sup> | Old World primates/good surgical anesthesia lasting 5-10 min                                                                                                                                                                                                                               |
|                                 | 12-18 mg/kg IM, IV <sup><a href="#">34,108,142</a></sup>                                                                                                  | Marmosets, small primates/heavy sedation, anesthesia                                                                                                                                                                                                                                       |
| Atipamezole (Antisedan, Pfizer) | IM use only                                                                                                                                               | Specific $\alpha_2$ -adrenergic antagonist; more specific for medetomidine and dexmedetomidine than for xylazine reversal; as a general rule, atipamezole is dosed at the same <i>volume</i> as medetomidine and dexmedetomidine, though they are manufactured at different concentrations |
| Atracurium                      | 0.09-1.5 mg/kg <sup><a href="#">9</a></sup> IV                                                                                                            | Macaques/non-depolarizing neuromuscular blocker; high dose produces histamine-like cardiovascular effects (sudden transient decrease in mean arterial pressure and increase in heart rate) and facial flushing                                                                             |
| Atropine                        | 0.02-0.05 mg/kg SC, IM, IV <sup><a href="#">109,111</a></sup>                                                                                             | New World primates/anticholinergic                                                                                                                                                                                                                                                         |
|                                 | 0.04 mg/kg SC, IM, IV <sup><a href="#">54</a></sup>                                                                                                       | Macaques, baboons                                                                                                                                                                                                                                                                          |
|                                 | 0.05 mg/kg IM <sup><a href="#">34</a></sup>                                                                                                               | Chimpanzees                                                                                                                                                                                                                                                                                |
| Bupivacaine (0.25%)             | 1 mg/kg local infiltration <sup><a href="#">109</a></sup>                                                                                                 | Intercostal nerve block                                                                                                                                                                                                                                                                    |
| Bupivacaine (0.5%)              | 1.2 mg/kg epidural <sup><a href="#">45</a></sup>                                                                                                          | Rhesus macaques/epidural analgesia                                                                                                                                                                                                                                                         |
|                                 |                                                                                                                                                           |                                                                                                                                                                                                                                                                                            |

|                                                   |                                                        |                                                                                                                                                                                                                                                                                                                                                                                          |
|---------------------------------------------------|--------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Buprenorphine                                     | 0.005-0.01 mg/kg SC, IM, IV q6-12h <sup>33,34,60</sup> | Agonist-antagonist opioid; analgesia <sup>61</sup><br>Great apes                                                                                                                                                                                                                                                                                                                         |
|                                                   | 0.01-0.03 mg/kg IM q6-12h <sup>111,117</sup>           | Galagos, owl monkeys, squirrel monkeys                                                                                                                                                                                                                                                                                                                                                   |
|                                                   | 0.015 mg/kg IM q6-8h <sup>111</sup>                    | New World primates                                                                                                                                                                                                                                                                                                                                                                       |
|                                                   | 0.02 mg/kg SC q6h <sup>111</sup>                       | New World primates                                                                                                                                                                                                                                                                                                                                                                       |
|                                                   | 0.3 mg/kg IM q8h <sup>3</sup>                          | Chimpanzees                                                                                                                                                                                                                                                                                                                                                                              |
| Butorphanol                                       | —                                                      | In primates, butorphanol displays a different pattern of receptor pharmacology; rather than being an antagonist at $\mu$ receptors, it behaves more as an agonist of intermediate efficacy; receptor binding studies have shown butorphanol has 12-fold $\mu$ to $\kappa$ selectivity and 34-fold $\mu$ to $\delta$ selectivity; <sup>55</sup> may cause profound respiratory depression |
|                                                   | 0.01 mg/kg IV q3-4h <sup>34</sup>                      | Duration of action uncertain                                                                                                                                                                                                                                                                                                                                                             |
|                                                   | 0.02 mg/kg SC q6h <sup>111</sup>                       | New World species                                                                                                                                                                                                                                                                                                                                                                        |
|                                                   | 0.02 mg/kg IM <sup>111</sup>                           | Chimpanzees/not to exceed 0.3 mg total                                                                                                                                                                                                                                                                                                                                                   |
|                                                   | 0.025 mg/kg IM q3-4h <sup>117</sup>                    |                                                                                                                                                                                                                                                                                                                                                                                          |
|                                                   | 0.05 mg/kg IM q8h <sup>3</sup>                         |                                                                                                                                                                                                                                                                                                                                                                                          |
|                                                   | 0.1-0.2 mg/kg IM q12-48h <sup>52</sup>                 |                                                                                                                                                                                                                                                                                                                                                                                          |
| Butorphanol (B)/acepromazine (A)                  | 0.02 mg/kg (A) + 0.013 mg/kg IM (B) <sup>15</sup>      | Macaques/premedication for inhalant anesthesia                                                                                                                                                                                                                                                                                                                                           |
| Carfentanil                                       | 0.3 $\mu$ g/kg IV <sup>109</sup>                       | Rhesus macaques/potent opioid; moderate sedation and analgesia; mild respiratory depression                                                                                                                                                                                                                                                                                              |
| Carprofen                                         | 2-4 mg/kg PO, SC q12-24h <sup>34,113</sup>             | Nonsteroidal antiinflammatory; analgesia                                                                                                                                                                                                                                                                                                                                                 |
|                                                   | 3-4 mg/kg SC, IV <sup>31</sup>                         | Preoperative                                                                                                                                                                                                                                                                                                                                                                             |
| Celecoxib                                         | 5 mg/kg <sup>19</sup>                                  | Nonsteroidal antiinflammatory; analgesia                                                                                                                                                                                                                                                                                                                                                 |
|                                                   | 200 mg/animal PO q12-24h <sup>3</sup>                  | Chimpanzees (adults)                                                                                                                                                                                                                                                                                                                                                                     |
| Chlorpromazine                                    | 1-6 mg/kg PO, IM <sup>44</sup>                         | Preanesthetic                                                                                                                                                                                                                                                                                                                                                                            |
| Deracoxib (Deramaxx, Novartis)                    | 4 mg/kg PO q24h <sup>3</sup>                           | Nonsteroidal antiinflammatory; analgesia; 2 mg/kg for chronic use                                                                                                                                                                                                                                                                                                                        |
| Dexmedetomidine <sup>a</sup> (Dexdomitor, Pfizer) | —                                                      | $\alpha_2$ agonist that has replaced medetomidine <sup>a</sup>                                                                                                                                                                                                                                                                                                                           |



|                                |                                                                       |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
|--------------------------------|-----------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Diazepam                       | —                                                                     | Used often as an adjuvant; see ketamine for combination                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |
|                                | 0.1-0.5 mg/kg IM <sup>52</sup>                                        | Lemurs/prevents ketamine-induced seizures                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
|                                | 0.25-0.5 mg/kg IM, IV <sup>59</sup>                                   |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
|                                | 0.5-1 mg/kg PO <sup>52</sup>                                          | Sedation; give in small amount of food or drink 30-60 min prior to anesthesia; degree of sedation variable; recovery prolonged                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
|                                | 1 mg/kg IM <sup>34</sup>                                              | Provides insufficient sedation as a single agent                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| Droperidol                     | 2.5-10 mg IM <sup>3</sup>                                             | Chimpanzees (adults)/given 30-60 min prior to procedure                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |
| Droperidol (D)/carfentanil (C) | (D) 2.5 mg PO + (C) 2 µg/kg PO transmucosally <sup>74</sup>           | Chimpanzees, bonobos (>20 kg)/used to eliminate or minimize stress of darting; followed at 25 min by darting with a combination of tiletamine/zolazepam and naltrexone; (D) was administered in grape juice, and transmucosal (C); was given directly onto oral mucous membrane via hand syringe; respiratory depression with low SpO <sub>2</sub> ; provide supplemental oxygen; warning: use (D)/(C) combination only as a premedication to tiletamine/zolazepam or ketamine anesthesia; the narcotic reversal agent must be given once animal reaches stage 4-5 anesthesia or at 25 min after dosing; naltrexone for reversal, 100× (C) dose in mg |
| Enflurane                      | 1 MAC=1.84% <sup>136</sup>                                            | Inhalant anesthetic; isoflurane or sevoflurane preferred                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
| Etomidate                      | —                                                                     | Decreases mean arterial pressure, heart rate, and myocardial contractility; increases systemic arterial compliance                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
|                                | 1 mg/kg IV <sup>28</sup>                                              | Induction                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
|                                | 100 µg/kg/min IV, constant rate infusion <sup>28</sup>                | Maintenance                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
| Fentanyl                       | —                                                                     | Fentanyl combinations follow                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
|                                | 0.13, 0.26, or 0.39 µg/kg/min IV constant rate infusion <sup>92</sup> | Use with isoflurane MAC (1.53% ± 0.07%); fentanyl sparing effect reduced isoflurane MAC by 19%, 44%, and 59%, respectively                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
|                                | 5-10 µg/kg/h IV constant rate infusion <sup>3</sup>                   | Chimpanzees                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
|                                | 5-10 µg/kg IV                                                         |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |

|                                            |                                                                                                                                                     |                                                                                                                                                    |
|--------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------|
|                                            | bolus, <a href="#">109,137</a> or 10-25 µg/kg/h constant rate infusion <sup><a href="#">81</a></sup>                                                | Rhesus macaques, baboons/use with isoflurane; side effects include bradycardia, hypotension                                                        |
| Fentanyl/droperidol (Innovar-Vet, Janssen) | 0.05-0.1 mL/kg IM, IV <sup><a href="#">67</a></sup>                                                                                                 | Preanesthetic; primates appear to be more sensitive to the drug than dogs; <sup><a href="#">30</a></sup> high doses produce respiratory depression |
|                                            | 0.1-0.3 mL/kg SC, IM <sup><a href="#">109</a></sup>                                                                                                 | Minor procedures                                                                                                                                   |
| Fentanyl/fluanisone (Hypnorm, Janssen)     | 0.3 mL/kg SC, IM <sup><a href="#">109</a></sup>                                                                                                     | Heavy sedation and good analgesia <sup><a href="#">34</a></sup>                                                                                    |
| Fentanyl transdermal patch                 | 25 µg/kg/h (5-10 kg), 50 µg/kg/h (10 kg) q48-72h <sup><a href="#">3</a></sup>                                                                       | Opioid analgesia                                                                                                                                   |
| Fentanyl (F)/vecuronium (V)/midazolam (Mi) | 1-5 µg/kg/h + (V) 1-3 mg/kg/h + (Mi) 0.05-0.1 mg/kg/h IV constant rate infusion <sup><a href="#">48</a></sup>                                       | Orangutans/immobilization                                                                                                                          |
| Flumazenil                                 | 0.025 mg/kg IV <sup><a href="#">56</a></sup>                                                                                                        | Benzodiazepine reversal                                                                                                                            |
| Flunixin meglumine                         | 0.3-1 mg/kg SC, IV q12-24h <sup><a href="#">52</a></sup>                                                                                            | Nonsteroidal antiinflammatory; analgesia                                                                                                           |
|                                            | 0.5 mg/kg IM q24h <sup><a href="#">29</a></sup>                                                                                                     | Prosimians                                                                                                                                         |
|                                            | 0.5-2 mg/kg SC, IV q24h <sup><a href="#">34</a></sup>                                                                                               |                                                                                                                                                    |
|                                            | 2 mg/kg IM q12h <sup><a href="#">3</a></sup>                                                                                                        |                                                                                                                                                    |
| Glycopyrrolate                             | 0.005-0.01 mg/kg IM <sup><a href="#">109</a></sup>                                                                                                  | Anticholinergic                                                                                                                                    |
| Ibuprofen                                  | 7 mg/kg PO q12h <sup><a href="#">3,34</a></sup>                                                                                                     | Nonsteroidal antiinflammatory; analgesia                                                                                                           |
|                                            | 200-400 mg/animal PO q8h <sup><a href="#">3</a></sup>                                                                                               | Chimpanzees                                                                                                                                        |
| Isoflurane                                 | 0.5-0.7% isoflurane with 8 µg/kg fentanyl <sup><a href="#">137</a></sup>                                                                            | Balanced anesthesia                                                                                                                                |
|                                            | 1-2% on 100% oxygen; 0.8-1.25% supplemented with 2:1 ration of N <sub>2</sub> O to oxygen for anesthesia maintenance <sup><a href="#">111</a></sup> | Baboons                                                                                                                                            |
|                                            | 1-3% maintenance <sup><a href="#">111</a></sup>                                                                                                     | Marmosets, chimpanzees                                                                                                                             |
|                                            |                                                                                                                                                     |                                                                                                                                                    |

|                                             |                                                                    |                                                                                                                                                                                                                    |
|---------------------------------------------|--------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                                             | 1 MAC = 1.28-1.46% <a href="#">129,136</a>                         | Macaques/inhalant anesthetic; no cardiovascular depression, but profound respiratory depression; 55% MAC reduction when used with 2 mg/kg morphine IV <a href="#">129</a>                                          |
|                                             | 3% mask induction and 0.5% maintenance <a href="#">111</a>         | Galagos/10-15 mg/kg ketamine IM for sedation to allow mask placement                                                                                                                                               |
|                                             | 4-5% for mask induction and 0.5-3% maintenance <a href="#">111</a> | Squirrel monkeys/induction takes less than 2 min                                                                                                                                                                   |
| Ketamine                                    | —                                                                  | Tranquilization; anesthesia; mg/kg dose increases as size of animal decreases; causes seizures in lemurs when used as sole agent (see diazepam, midazolam, ketamine/acepromazine); ketamine combinations follow    |
|                                             | 5 mg/kg IM <a href="#">52</a>                                      | Great apes/immobilization; follow with inhalant anesthetic; used in field immobilization of free-living mountain gorillas; ketamine provides a shorter recovery time than tiletamine/zolazepam <a href="#">125</a> |
|                                             | 5-25 mg/kg IM <a href="#">7,34,143</a>                             | Larger primates/moderate sedation, immobilization, some analgesia                                                                                                                                                  |
|                                             | 10-15 mg/kg IM <a href="#">52</a>                                  | New World primates, <a href="#">3</a> medium-size primates (10-30 kg)/immobilization; follow with inhalant anesthetic <a href="#">34</a>                                                                           |
| Ketamine (K)/acepromazine (A)               | (K) 4 mg/kg + (A) 0.04 mg/kg IM <a href="#">29</a>                 | Lemurs                                                                                                                                                                                                             |
| Ketamine (K)/diazepam (D)                   | (K) 15 mg/kg + (D) 1 mg/kg IM <a href="#">32</a>                   | Surgical anesthesia with good muscle relaxation lasting 30-40 min <a href="#">33,34</a>                                                                                                                            |
| Ketamine (K)/medetomidine <sup>a</sup> (Me) | —                                                                  | Medetomidine is no longer commercially available, but can be compounded; <sup>a</sup> has been replaced with dexmedetomidine                                                                                       |
|                                             | (K) 2-6 mg/kg IM + (Me) 0.03-0.06 mg/kg IM <a href="#">83</a>      | Chimpanzees                                                                                                                                                                                                        |
|                                             | (K) 5-7.5 mg/kg IM + (Me) 0.033-0.075 mg/kg IM <a href="#">122</a> | Use higher dosages for smaller primates                                                                                                                                                                            |
|                                             | (K) 5-10 mg/kg IM + (Me) 0.05-0.1 mg/kg IM, IV <a href="#">21</a>  |                                                                                                                                                                                                                    |
| Ketamine                                    |                                                                    | Medetomidine is no longer commercially                                                                                                                                                                             |

|                                                       |                                                                                     |                                                                                                                                                       |
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| (K)/medetomidine <sup>a</sup><br>(Me)/butorphanol (B) | —                                                                                   | available, but can be compounded; <sup>a</sup> has been replaced with dexmedetomidine                                                                 |
|                                                       | (K) 3 mg/kg IM +<br>(Me) 0.04 mg/kg IM +<br>(B) 0.4 mg/kg IM <sup>144</sup>         | Ring-tailed lemurs/anesthesia; long duration of action; rapid and complete reversibility with specific antagonists                                    |
| Ketamine<br>(K)/midazolam (Mi)                        | (K) 8 mg/kg IM +<br>(Mi) 0.2 mg/kg <sup>4</sup>                                     | Macaques                                                                                                                                              |
|                                                       | (K) 10 mg/kg + (Mi) 1 mg/kg IM <sup>40</sup>                                        | Marmosets                                                                                                                                             |
|                                                       | (K) 15 mg/kg IM +<br>(Mi) 0.05-0.2 mg SC, IM, <sup>60</sup> IV <sup>62</sup>        |                                                                                                                                                       |
| Ketamine (K)/xylazine<br>(X)                          | (K) 10 mg/kg + (X) 0.5 mg/kg IM <sup>32</sup>                                       | Surgical anesthesia with good muscle relaxation lasting 30-40 min; xylazine can be reversed with atipamezole, <sup>34</sup> or, preferably, yohimbine |
|                                                       | (K) 10-20 mg/kg IM +<br>(X) 3 mg/kg IM <sup>3</sup>                                 | New World primates                                                                                                                                    |
|                                                       | (K) 15-20 mg/kg IM +<br>(X) 1 mg/kg IM <sup>3</sup>                                 | Chimpanzees                                                                                                                                           |
| Ketoprofen                                            | 2 mg/kg IM, IV q24h <sup>34</sup>                                                   | Nonsteroidal antiinflammatory; analgesia                                                                                                              |
|                                                       | 5 mg/kg IM q6-8h <sup>113</sup>                                                     |                                                                                                                                                       |
| Ketorolac (Torador, Syntex)                           | 0.5-1 mg/kg SC, IM q8-12h <sup>111</sup>                                            | Nonsteroidal antiinflammatory                                                                                                                         |
|                                                       | 15-30 mg/animal <sup>113</sup> initially; then 10-15 mg/animal q8h <sup>3,111</sup> | Macaques, baboons                                                                                                                                     |
|                                                       | 15-30 mg/animal IM <sup>36,111</sup>                                                | Baboons                                                                                                                                               |
|                                                       | 30 mg/animal PO q6h, or single dose 60 mg <sup>3,111</sup>                          | Chimpanzees                                                                                                                                           |
| Medetomidine <sup>a</sup>                             | —                                                                                   | $\alpha_2$ agonist; no longer commercially available, but can be compounded <sup>d</sup>                                                              |
| Meloxicam (Metacam, Boehringer Ingelheim)             | 0.1-0.2 mg/kg PO, SC q24h <sup>34</sup>                                             | Nonsteroidal antiinflammatory; analgesia                                                                                                              |
| Meperidine                                            | 2-4 mg/kg IM, IV q2-4h <sup>34</sup> or q3-4h <sup>52,117</sup>                     | Analgesia; caution: sudden death reported in healthy animals <sup>117</sup>                                                                           |
|                                                       | 50-150 mg/animal PO q3-4h <sup>3</sup>                                              | Chimpanzees                                                                                                                                           |

|                             |                                                                                            |                                                                                                                                                                                         |
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| Methohexitone               | 10 mg/kg IV <sup><a href="#">34</a></sup>                                                  | Surgical anesthesia, 5-10 min; reduce dose by at least 50% if ketamine is being used as a preanesthetic                                                                                 |
| Midazolam                   | —                                                                                          | See ketamine and fentanyl for combinations                                                                                                                                              |
|                             | 0.05-0.1 mg/kg IM, IV <sup><a href="#">3</a></sup>                                         |                                                                                                                                                                                         |
|                             | 0.1-0.5 mg/kg IM <sup><a href="#">52</a></sup>                                             | Lemurs/prevents ketamine-induced seizures                                                                                                                                               |
|                             | 0.2-0.4 mg/kg IV bolus <sup><a href="#">109</a></sup>                                      | Balanced anesthetic technique with fentanyl (1-2 µg/kg IV bolus)                                                                                                                        |
|                             | 1-2.5 mg/animal IV <sup><a href="#">3</a></sup>                                            | Chimpanzees                                                                                                                                                                             |
|                             | 5 mg/animal IM <sup><a href="#">3</a></sup>                                                | Chimpanzees                                                                                                                                                                             |
| Morphine                    | —                                                                                          | Opioid analgesia; dose dependent respiratory depression; use with care, especially in New World primates; may cause intense pruritis around eyes and nose <sup><a href="#">55</a></sup> |
|                             | 0.125-1 mg/kg IV <sup><a href="#">109</a></sup>                                            | Squirrel monkeys                                                                                                                                                                        |
|                             | 0.5 mg/kg/day IV constant rate infusion <sup><a href="#">110</a></sup>                     | Baboons                                                                                                                                                                                 |
|                             | 1-2 mg/kg PO, SC, IM, IV q4h <sup><a href="#">34,117</a></sup>                             |                                                                                                                                                                                         |
| Morphine, preservative free | 0.01 mg/kg <sup><a href="#">109</a></sup>                                                  | Intrathecal analgesia                                                                                                                                                                   |
|                             | 0.1 mg/kg or 0.5 mg/kg/day for 48 hr constant rate infusion <sup><a href="#">109</a></sup> | Epidural analgesia                                                                                                                                                                      |
| Nalbuphine                  | 0.5 mg/kg IM, IV q3-6h <sup><a href="#">52</a></sup>                                       |                                                                                                                                                                                         |
|                             | 2.5-5 mg/kg IM q3-4h <sup>3</sup>                                                          | Agonist-antagonist opioid                                                                                                                                                               |
|                             | 10 mg/animal SC, IM, IV q3-6h <sup><a href="#">3</a></sup> prn                             | Chimpanzees                                                                                                                                                                             |
| Naloxone                    | —                                                                                          | Opioid antagonist/reversal; short acting, a second dose may be necessary to avoid the return of respiratory depression <sup><a href="#">111</a></sup>                                   |
|                             | 0.015 mg/kg SC, IM, IV <sup><a href="#">111</a></sup>                                      | Chimpanzees                                                                                                                                                                             |
|                             | 0.1 mg/kg SC, IM, IV prn <sup><a href="#">3</a></sup>                                      |                                                                                                                                                                                         |

|                                  |                                                                                                |                                                                                                                                                                   |
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|                                  | 0.1-0.2 mg/kg IM, IV <sup><a href="#">111</a></sup>                                            |                                                                                                                                                                   |
| Naproxen                         | —                                                                                              | Nonsteroidal antiinflammatory; analgesia; antipyretic                                                                                                             |
|                                  | 5 mg/kg PO 24h <sup><a href="#">3</a></sup>                                                    | Chimpanzees                                                                                                                                                       |
|                                  | 10 mg/kg PO q12h <sup><a href="#">65,72</a></sup>                                              | Lemurs                                                                                                                                                            |
| Neostigmine                      | 0.1 mg/kg IV <sup><a href="#">52</a></sup>                                                     | Anticholinesterase; antidote for nondepolarizing neuromuscular blocking agent; side effect: marked bradycardia; can be used with or without anticholinergic drugs |
| Nitrous oxide (N <sub>2</sub> O) | Up to 60% with O <sub>2</sub> (minimum total flow 200 mL/kg/min) <sup><a href="#">60</a></sup> | Use of O <sub>2</sub> analyzer is advisable                                                                                                                       |
|                                  | 1 MAC = 200% <sup><a href="#">109</a></sup>                                                    | Macaques                                                                                                                                                          |
|                                  | 30% N <sub>2</sub> O reduced MAC enflurane 1.46% (from 1.84%) <sup><a href="#">130</a></sup>   | Macaques                                                                                                                                                          |
| Oxymorphone                      | —                                                                                              | Opioid analgesia                                                                                                                                                  |
|                                  | 0.025 mg/kg SC, IM, IV q4-6h <sup><a href="#">3</a></sup>                                      | New World primates                                                                                                                                                |
|                                  | 0.075 mg/kg IM q4-6h <sup><a href="#">111</a></sup>                                            | New World primates                                                                                                                                                |
|                                  | 0.15 mg/kg SC, IM, IV q4-6h <sup><a href="#">34,61</a></sup>                                   | Old World primates                                                                                                                                                |
|                                  | 1-1.5 mg/animal SC, IM q4h <sup><a href="#">111</a></sup>                                      | Chimpanzees <sup><a href="#">111</a></sup>                                                                                                                        |
| Pancuronium                      | 0.04-0.1 mg/kg IV <sup><a href="#">109</a></sup>                                               | Non-depolarizing neuromuscular blocker; requires assisted ventilation; use with caution                                                                           |
| Paracetamol                      | 5-10 mg/kg PO q6h <sup><a href="#">135</a></sup>                                               | Analgesia                                                                                                                                                         |
| Pentazocine                      | 2-5 mg/kg IM, IV q4h <sup><a href="#">34,52</a></sup>                                          | Analgesia                                                                                                                                                         |
| Pentobarbital sodium             | —                                                                                              | There is considerable variation between species; severe respiratory depression; inability to modulate depth of anesthesia; prolonged recovery                     |
|                                  | 15 mg/kg IV slowly to effect <sup><a href="#">111</a></sup>                                    | New World primates                                                                                                                                                |
|                                  | 20-30 mg/kg IV; decrease to 11 mg/kg if precede with                                           |                                                                                                                                                                   |

|                        |                                                                                                                                              |                                                                                                                                                                                                                                                                                            |
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|                        | ketamine 20 mg/kg<br>IM <sup><a href="#">111</a></sup>                                                                                       |                                                                                                                                                                                                                                                                                            |
|                        | 25 mg/kg IV (adults),<br>15 mg/kg IV<br>(juveniles); slowly to<br>effect <sup><a href="#">111</a></sup>                                      | Baboons                                                                                                                                                                                                                                                                                    |
|                        | 25-35 mg/kg IV <sup><a href="#">33,34</a></sup>                                                                                              | 30-60 min light surgical anesthesia, but severe<br>respiratory depression often occurs at higher dose;<br>recovery can be prolonged, especially if<br>incremental doses are administered; the dose<br>should be reduced at least 50% if ketamine or other<br>preanesthetics have been used |
|                        | 100 mg/animal slow<br>IV <sup><a href="#">111</a></sup>                                                                                      | Chimpanzees/not to exceed 50 mg/min                                                                                                                                                                                                                                                        |
| Pentobarbitone         | —                                                                                                                                            | See pentobarbital                                                                                                                                                                                                                                                                          |
| Pethidine (meperidine) | —                                                                                                                                            | See meperidine                                                                                                                                                                                                                                                                             |
| Propofol               | 2.5-5 mg kg IV bolus;<br>maintenance with 0.3-<br>0.4 mg/kg/min IV<br>constant rate<br>infusion <sup><a href="#">11,38,109,111,119</a></sup> | Baboons, macaques                                                                                                                                                                                                                                                                          |
|                        | 7-8 mg/kg IV <sup><a href="#">34</a></sup>                                                                                                   | Marmosets, larger primates/induction and<br>maintenance of anesthesia; good surgical<br>anesthesia and rapid smooth recovery <sup><a href="#">38,44</a></sup>                                                                                                                              |
|                        | 1-2 mg/kg IV bolus,<br>followed by infusion<br>to effect <sup><a href="#">109</a></sup>                                                      | Chimpanzees                                                                                                                                                                                                                                                                                |
|                        | 2 mg/kg IV bolus;<br>maintenance with 0.2<br>mg/kg/min IV<br>constant rate<br>infusion <sup><a href="#">28</a></sup>                         | Decreases mean arterial pressure, heart rate, and<br>myocardial contractility; increases systemic<br>arterial compliance                                                                                                                                                                   |
|                        | 5 mg/kg IV bolus;<br>maintenance with 0.4<br>mg/kg/min constant<br>rate infusion <sup><a href="#">37</a></sup>                               | Macaques                                                                                                                                                                                                                                                                                   |
| Sevoflurane            | 1 MAC=2% <sup><a href="#">126</a></sup>                                                                                                      | Macaques                                                                                                                                                                                                                                                                                   |
|                        | 8% mask induction;<br>2.5%<br>maintenance <sup><a href="#">80,126</a></sup>                                                                  | Garnett's greater bushbaby/rapid induction and<br>recovery; no significant cardiopulmonary effects;<br>significant decrease in body temperature, WBC<br>count, calcium, and total protein within 30 min of<br>anesthesia                                                                   |

|                                            |                                                                                             |                                                                                                                                                   |
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| Succinylcholine                            | 2 mg/kg IV <sup><a href="#">50</a></sup>                                                    | Depolarizing neuromuscular agent; requires assisted ventilation; use with caution                                                                 |
| Thiamylal sodium                           | 15-25 mg/kg IV to effect <sup><a href="#">3,67</a></sup>                                    | Barbiturate anesthesia                                                                                                                            |
| Thiopental                                 | 3-5 mg kg IV <sup><a href="#">111</a></sup>                                                 | Barbiturate anesthesia; induction agent for inhalation anesthesia; only human-labeled product available                                           |
|                                            | 10-15 mg/kg IV bolus; 5-7 mg/kg IV if combined with ketamine <sup><a href="#">109</a></sup> |                                                                                                                                                   |
|                                            | 15-17 mg/kg/h IV constant rate infusion <sup><a href="#">109</a></sup>                      |                                                                                                                                                   |
|                                            | 15-20 mg/kg IV <sup><a href="#">33</a></sup>                                                | Barbiturate anesthesia; surgical anesthesia, 5-10 min; reduce dose by at least 50% if ketamine used as premedication                              |
|                                            | 25 mg/kg IV to effect <sup><a href="#">67</a></sup>                                         |                                                                                                                                                   |
| Thiopentone                                | —                                                                                           | See thiopental                                                                                                                                    |
| Tiletamine/zolazepam (Telazol, Fort Dodge) | 1-2.5 mg/kg IM <sup><a href="#">3</a></sup>                                                 | New World primates                                                                                                                                |
|                                            | 1.5-3 mg/kg IM <sup><a href="#">16</a></sup>                                                | Macaques                                                                                                                                          |
|                                            | 3-5 mg/kg IM <sup><a href="#">82,123</a></sup>                                              | Great apes/gorillas can experience severe ataxia during the recovery period, putting them at serious risk of injury <sup><a href="#">55</a></sup> |
|                                            | 4-6 mg/kg IM <sup><a href="#">23</a></sup>                                                  | Macaques, baboons, patas monkeys/chemical restraint 45, 60, and 100 min respectively; marked hypothermia reported <sup><a href="#">88</a></sup>   |
| Tramadol                                   | 1-2 mg/kg SC, IV <sup><a href="#">34</a></sup>                                              | Duration of action uncertain                                                                                                                      |
|                                            | 2 mg/kg PO q12h <sup><a href="#">34</a></sup>                                               |                                                                                                                                                   |
| Tubocurarine                               | 0.09 mg/kg IV <sup><a href="#">50</a></sup>                                                 | Non-depolarizing neuromuscular blocking agent; requires assisted ventilation; use with caution                                                    |
| Vecuronium (Norcuron, Organon)             | 0.04-0.06 mg/kg IV <sup><a href="#">111</a></sup>                                           | Non-depolarizing neuromuscular blocking agent; requires assisted ventilation; has no hemodynamic effects                                          |
| Xylazine                                   | —                                                                                           | See ketamine for combination                                                                                                                      |
|                                            | 0.5 mg/kg IM, <sup><a href="#">3</a></sup> IV <sup><a href="#">109</a></sup>                | Light to moderate sedation; some analgesia                                                                                                        |
|                                            | 1.1 mg/kg IV <sup><a href="#">3</a></sup>                                                   | Chimpanzees                                                                                                                                       |
|                                            | 2.2 mg kg IM <sup><a href="#">3</a></sup>                                                   | Chimpanzees                                                                                                                                       |
|                                            | 0.5 mg/kg IV or 1                                                                           |                                                                                                                                                   |



<sup>a</sup> Medetomidine is no longer commercially available although it can be obtained from select compounding services (i.e., Diamondback Drugs, [www.diamondbackdrugs.com](http://www.diamondbackdrugs.com); Wildlife Pharmaceuticals, [www.wildpharm.com](http://www.wildpharm.com)); dosages are listed here as a guide for possible use with dexmedetomidine, an  $\alpha_2$  agonist that is the active optical enantiomer of racemic compound medetomidine; dexmedetomidine is used at ½ the dose of medetomidine but the same volume due to higher concentration; although the same effects would be expected as with medetomidine, there is limited data on the efficacy and safety of dexmedetomidine in primates; the effects of the v/v use of the two drugs may not be equivalent, so the dose of dexmedetomidine may need to be adjusted based on clinical response.

TABLE 12-4 Miscellaneous Agents Used in Primates.

| Agent                                | Dosage                                                     | Species/Comments                                                                                                      |
|--------------------------------------|------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------|
| Acetylcysteine (Mucomyst, Apothecon) | 50-60 mL/h via nebulization × 30-60 min q12h <sup>67</sup> | Mucolytic                                                                                                             |
| Aminophylline                        | 10 mg/kg IV <sup>29</sup>                                  | Lemurs/bronchodilation                                                                                                |
|                                      | 25-100 mg/animal PO q12h <sup>67</sup>                     | Bronchodilation                                                                                                       |
| Atropine sulfate                     | 0.02-0.05 mg/kg SC, IM, IV <sup>109</sup>                  | Anticholinergic; reduces secretions; prevents bradycardia                                                             |
| Azathioprine                         | 1-2 mg/kg PO q24h <sup>3</sup>                             | Immunosuppressive agent; purine antagonist                                                                            |
| Bismuth subsalicylate                | —                                                          | Intestinal protectant; gastrointestinal ulcers                                                                        |
|                                      | 10 mg/kg PO q12h <sup>25</sup>                             |                                                                                                                       |
|                                      | 17.5 mg/kg PO q6-8h <sup>65</sup>                          |                                                                                                                       |
|                                      | 40 mg/kg PO q8-12h <sup>3</sup>                            |                                                                                                                       |
| Calcium chloride                     | 10-20 mg/kg IV (slow) <sup>118</sup>                       | Emergency treatment for hypocalcemia (monitor heart rate closely); cardiogenic; reverses aminoglycoside-induced shock |
| Calcium gluconate                    | 200 mg/kg SC, IM, IV <sup>118</sup>                        | Hypocalcemia; hyperkalemia; prophylaxis and therapy of nutritional secondary hyperparathyroidism                      |
| Captopril                            | 1 mg/kg PO <sup>118</sup>                                  | Angiotensin converting enzyme (ACE) inhibitor; vasodilator                                                            |
|                                      | 0.5 mg/kg q24h PO, in                                      |                                                                                                                       |

|                                                  |                                                              |                                                                                                                                                                                                         |
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| Chlorpheniramine                                 | divided doses <sup>67</sup>                                  | Antihistamine; H <sub>1</sub> receptor antagonist                                                                                                                                                       |
| Chlorpromazine                                   | 1-3 mg/kg IM <sup>95</sup>                                   | Antiemetic                                                                                                                                                                                              |
| Cimetidine                                       | 10 mg/kg PO, <sup>3</sup> SC, IM q8h <sup>14</sup>           | H <sub>2</sub> receptor antagonist; gastrointestinal ulceration                                                                                                                                         |
| Cisapride (Propulsid, Janssen)                   | 0.2 mg/kg PO q12h <sup>57</sup>                              | Macaques/promotes gastrointestinal motility; limited availability in the United States; can be compounded                                                                                               |
| Dexamethasone                                    | 0.25-1 mg/kg PO, IM <sup>95</sup>                            | Antiinflammatory                                                                                                                                                                                        |
|                                                  | ≤2 mg/kg PO, IM, IV <sup>67</sup>                            | Antiinflammatory                                                                                                                                                                                        |
| Digoxin                                          | 2-12 µg/kg IM, IV divided q12-24h <sup>3</sup>               | Maintenance                                                                                                                                                                                             |
| Dimercapto-succinic acid (DMSA) (Chemet, McNeil) | 10 mg/kg PO q8h × 5 days, then q12h × 14 days <sup>149</sup> | Chimpanzees/lead chelation                                                                                                                                                                              |
| Diphenhydramine                                  | 5 mg/kg IM <sup>29</sup>                                     | Lemurs/antihistamine                                                                                                                                                                                    |
|                                                  | 5 mg/kg/day PO, IM, IV q6-8h <sup>3</sup>                    |                                                                                                                                                                                                         |
|                                                  | 25-50 mg/animal PO, IM, IV q6-8h <sup>3</sup>                | Chimpanzees (adults)                                                                                                                                                                                    |
| Diphenoxylate/atropine (Lomotil, Searle)         | 1 mL/animal PO q8h <sup>52</sup>                             | Opiate; antidiarrheal                                                                                                                                                                                   |
| Dobutamine                                       | 2-10 µg/kg/min IV constant rate infusion <sup>109</sup>      | Adrenergic β <sub>1</sub> agonist; increases cardiac output                                                                                                                                             |
| Dopamine                                         | 2-5 µg/kg/min IV constant rate infusion <sup>109</sup>       | Low to moderate doses result in cardiac stimulation (positive inotropic effects) and renal and mesenteric vasodilation; augments cardiac contractility and increases renal perfusion and urinary output |
|                                                  | 10 µg/kg/min IV constant rate infusion <sup>36</sup>         | High doses result in increased peripheral resistance and renal vasoconstriction; bradycardia after cardiac arrest                                                                                       |
| Doxapram                                         | 2 mg/kg IV <sup>32</sup>                                     | Respiratory stimulant                                                                                                                                                                                   |
| Enalapril (Enacard, Merck)                       | 0.015-0.125 mg/kg PO q12-24h <sup>97</sup>                   | Western lowland gorillas/antihypertensive                                                                                                                                                               |
|                                                  | 0.3 mg/kg PO, IV <sup>118</sup>                              | Angiotensin converting enzyme (ACE) inhibitor; balanced vasodilator                                                                                                                                     |
| Ephedrine                                        | 1.25-2.5 mg/kg IV <sup>36,109</sup>                          | Macaques, baboons/vasopressor; hypotension accompanied by bradycardia                                                                                                                                   |
|                                                  | 12 mg/kg PO q4h <sup>67</sup>                                | Nasal congestion; bronchoconstriction                                                                                                                                                                   |
|                                                  | 0.2-0.4 mg/kg diluted in 5                                   |                                                                                                                                                                                                         |

|                                           |                                                                                                                                |                                                                                       |
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| Epinephrine                               | mL sterile water, IT <sup><a href="#">36</a></sup> if ≥3 kg                                                                    | Cardiac arrest                                                                        |
|                                           | 0.5-1 mL IV <sup><a href="#">36</a></sup>                                                                                      | 1:10,000 dilution                                                                     |
| Erythropoietin, recombinant               | 50-100 U/kg SC, IV 3×/wk <sup><a href="#">3</a></sup>                                                                          | Treatment of non-regenerative anemia                                                  |
| Famotidine (Pepcid, Merck)                | 0.5-0.8 mg/kg PO q24h <sup><a href="#">99</a></sup>                                                                            | Mild gastroenteritis; gastrointestinal ulcers                                         |
| Flavored drink, cherry (Koolaid)          | PO prn <sup><a href="#">35</a></sup>                                                                                           | Mix with medication to enhance flavor; mix at 4× normal concentration                 |
| Flavored drink, grape (Syrpalta, Emerson) | PO prn <sup><a href="#">103</a></sup>                                                                                          | Mix as needed to flavor liquid medications and crushed tablets                        |
| Flavored drink, orange (Tang)             | PO prn <sup><a href="#">18,35</a></sup>                                                                                        | Add electrolyte salts to provide an oral hydration solution                           |
| Fluoxetine (Prozac, Eli Lilly)            | 0.45 mg/kg PO q24h <sup><a href="#">138</a></sup>                                                                              | Antianxiety                                                                           |
|                                           | 2 mg/kg PO or nasogastric intubation q24h <sup><a href="#">81</a></sup>                                                        | Rhesus macaques (juveniles)                                                           |
| Folic acid                                | 0.04-0.2 mg/kg PO q24h <sup><a href="#">65</a></sup>                                                                           | Supplement during pyrimethamine therapy                                               |
| Furosemide                                | 1-2 mg/kg IV <sup><a href="#">36,134</a></sup>                                                                                 | Diuresis; heart failure; pulmonary edema                                              |
|                                           | 1-4 mg/kg IV <sup><a href="#">3</a></sup>                                                                                      | Loop diuretic                                                                         |
|                                           | 2 mg/kg PO <sup><a href="#">67</a></sup>                                                                                       |                                                                                       |
|                                           | 2-4 mg/kg IM q8h <sup><a href="#">3</a></sup>                                                                                  |                                                                                       |
|                                           | 2-4 mg/kg PO q12-24h <sup><a href="#">134</a></sup>                                                                            | Owl monkeys                                                                           |
| Glipizide (Glucotrol, Pfizer)             | 1.1 mg/kg PO q24h <sup><a href="#">42</a></sup>                                                                                | Titi monkeys/anti-hyperglycemic sulfonylurea; non–insulin-dependent diabetes mellitus |
| Glycopyrrolate                            | 0.005-0.01 mg/kg IM <sup><a href="#">109</a></sup>                                                                             | Anticholinergic                                                                       |
| Guanfacine                                | —                                                                                                                              | Self-injurious behavior; decreases agitation without profound sedation                |
|                                           | 0.3 mg/kg PO, IM q12h × 5-10 days, followed by gradual reduction to 0.15 mg/kg q24h over 30 days <sup><a href="#">90</a></sup> | Baboons                                                                               |
|                                           | 0.5 mg/kg PO, IM q12h × 5-10 days, followed by gradual reduction to 0.25 mg/kg q24h over 30 days <sup><a href="#">90</a></sup> | Macaques                                                                              |
| Haloperidol (Haldol, McNeil)              | 0.03-0.05 mg/kg IM q12h <sup><a href="#">18</a></sup>                                                                          | Macaques/self-injurious behavior                                                      |
|                                           | 0.5-2 mg/kg IM <sup><a href="#">118</a></sup>                                                                                  | Vervets, green monkeys/antianxiety                                                    |
|                                           |                                                                                                                                |                                                                                       |

|                                    |                                                                              |                                                                                                                                                                                                                                            |
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| Human chorionic gonadotropin (hCG) | 250 U IM <sup><a href="#">118</a></sup>                                      | Squirrel monkeys/induced ovulation in 40% of the monkeys                                                                                                                                                                                   |
| Hydrocodone bitartrate             | 5 mg/animal PO q4-6h <sup><a href="#">3</a></sup>                            | Chimpanzees (adults)                                                                                                                                                                                                                       |
| Hydrocortisone sodium succinate    | 5 mg/animal IM, IV q12h <sup><a href="#">3</a></sup>                         | Chimpanzees (adults)                                                                                                                                                                                                                       |
| Insulin, NPH                       | 0.25-0.5 U/kg/day SC starting dose <sup><a href="#">65</a></sup>             | Diabetes mellitus; diabetic ketoacidosis                                                                                                                                                                                                   |
|                                    | 1.25 U/animal q12h IM <sup><a href="#">139</a></sup>                         | Macaques/use combination of short-acting and longer acting insulin (70:30); dose is highly variable (depending on individual, phase of disease, and concurrent medical conditions) and should be adjusted according to standard guidelines |
| Isoproterenol                      | 0.01-0.03 µg/kg/min IV constant rate infusion <sup><a href="#">106</a></sup> | Nonselective β-adrenergic agonist                                                                                                                                                                                                          |
|                                    | 0.05-2 µg/kg/min IV constant rate infusion <sup><a href="#">3</a></sup>      |                                                                                                                                                                                                                                            |
| Kaolin/pectin                      | 0.5-1 mL/kg PO q2-6h <sup><a href="#">61</a></sup>                           | Intestinal protectant                                                                                                                                                                                                                      |
| Leuprolide                         | 0.3 mg/kg IM q4wk <sup><a href="#">3</a></sup>                               |                                                                                                                                                                                                                                            |
| Levothyroxine                      | 0.01 mg/kg PO q12h <sup><a href="#">79</a></sup>                             | Hypothyroidism                                                                                                                                                                                                                             |
|                                    | 0.05 mg/animal PO q24h <sup><a href="#">78</a></sup>                         | Gorillas/hypothyroidism; after initial dosing, institute incremental changes of 0.025 mg q24h at 30-day intervals up to 0.1 mg q24h; monitor TSH and T <sub>4</sub> q6-8wk                                                                 |
| Lidocaine                          | 20-50 ug/kg/min IV constant rate infusion <sup><a href="#">109</a></sup>     | Ventricular arrhythmias; premature ventricular contractions                                                                                                                                                                                |
|                                    | 1-2 mg/kg IV bolus <sup><a href="#">36</a></sup>                             |                                                                                                                                                                                                                                            |
| Loperamide                         | 0.04 mg/kg PO q8h <sup><a href="#">3</a></sup>                               |                                                                                                                                                                                                                                            |
| Mannitol (25%)                     | 0.25-1 g/kg IV bolus over 20 min <sup><a href="#">18</a></sup>               | Osmotic diuresis; reduces intracranial pressure                                                                                                                                                                                            |
| Medroxyprogesterone acetate        | —                                                                            | Contraceptive                                                                                                                                                                                                                              |
|                                    | 5-10 mg/animal PO q24h × 5-10 days <sup><a href="#">3</a></sup>              |                                                                                                                                                                                                                                            |
|                                    | 150 mg/animal IM q3mo <sup><a href="#">3</a></sup>                           | Chimpanzees                                                                                                                                                                                                                                |
| Metoclopramide                     | 0.2-0.5 mg/kg IM q8-24h <sup><a href="#">3</a></sup>                         | Antiemetic; stimulates motility of upper gastrointestinal tract                                                                                                                                                                            |
| Nitroprusside                      | 1-4 µg/kg/min IV constant rate infusion <sup><a href="#">109</a></sup>       | Vasodilator; antihypertensive                                                                                                                                                                                                              |
| Norepinephrine                     | 0.05-0.1 µg/kg/min IV constant rate infusion <sup><a href="#">36</a></sup>   | Hypotension                                                                                                                                                                                                                                |

|                                                                    |                                                                                                              |                                                                                                                                                                                                               |
|--------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Omeprazole                                                         | 0.4 mg/kg PO q12h <sup>25</sup>                                                                              | Macaques/gastric acid suppressant; proton pump inhibitor; use as part of quadruple therapy for <i>Helicobacter pylori</i> infection                                                                           |
| Ondansetron                                                        | 1-2 mg/kg PO × 2 doses; prior and after radiation treatment <sup>94</sup>                                    | Macaques/antiemetic                                                                                                                                                                                           |
| Oxytocin                                                           | 0.5-1 U/min IV constant rate infusion <sup>3</sup>                                                           | Chimpanzees                                                                                                                                                                                                   |
|                                                                    | 2 U/animal IM <sup>18</sup>                                                                                  | Macaques/induction of late term abortion (open cervix); repeat q2h maximum 3 treatments; monitor dam closely; provide concurrent analgesia; expulsion of retained placenta (within 12-24 hr); uterine inertia |
|                                                                    | 5-20 U/animal IM, IV <sup>95</sup>                                                                           | Uterine inertia                                                                                                                                                                                               |
|                                                                    | 5-30 U/animal SC, IV prn <sup>3</sup>                                                                        | Chimpanzees                                                                                                                                                                                                   |
| Paroxetine (Paxil, SmithKline Beecham)                             | 0.3 mg/kg PO q12h <sup>138</sup>                                                                             | Antianxiety                                                                                                                                                                                                   |
| PGF <sub>2</sub> alpha                                             | 1 mg/kg IM q24h <sup>3</sup>                                                                                 | Soften cervix prior to chemically inducing labor                                                                                                                                                              |
| Phenobarbital                                                      | 0.6 mg/kg PO q24h <sup>69</sup>                                                                              | Prosimians/anticonvulsant                                                                                                                                                                                     |
| Phenylephrine                                                      | 1-2 µg/kg IV bolus, followed by 0.5-1 µg/kg/min IV constant rate infusion <sup>36,109</sup>                  | Hypotension                                                                                                                                                                                                   |
| Phenylephrine (Neo-Synephrine, Winthrop)                           | Intranasal q6h <sup>64</sup>                                                                                 | Nasal congestion                                                                                                                                                                                              |
| Phenytoin                                                          | 2.5 mg/kg PO q12h, increase <sup>3</sup>                                                                     | Cardiac antiarrhythmic                                                                                                                                                                                        |
| Polysulfated glycosaminoglycan (Adequan, Luitpold Pharmaceuticals) | 2 mg/kg IM q3-5d × 2-3 mo <sup>3</sup>                                                                       | Proteolytic enzyme inhibitor used for noninfectious degenerative and/or traumatic arthritis                                                                                                                   |
| Prednisolone sodium succinate (Solu-Delta Cortef, Upjohn)          | 1-15 mg/kg IV <sup>95</sup>                                                                                  | All species/shock                                                                                                                                                                                             |
|                                                                    | 10 mg/kg IV <sup>29</sup>                                                                                    | Lemurs/shock                                                                                                                                                                                                  |
| Prednisone                                                         | 0.5-1 mg/kg PO q12h × 3-5 days, then q24h × 3-5 days, then q48h × 10 days, then ½ dose q48h <sup>61,65</sup> | Lower doses for pain, inflammation; higher doses for autoimmune, inflammatory bowel disease, etc.                                                                                                             |
|                                                                    | 0.5-2 mg/kg PO <sup>3</sup>                                                                                  |                                                                                                                                                                                                               |
| Prochlorperazine                                                   | 0.12 mg/kg IM, IV <sup>3</sup>                                                                               | Antiemetic                                                                                                                                                                                                    |
|                                                                    |                                                                                                              | Administer slowly to avoid profound                                                                                                                                                                           |

|                                  |                                                                                                                                         |                                                                                                                                                                                                                       |
|----------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Protamine                        | 1 mg/80 U heparin IV <sup>109</sup>                                                                                                     | hypotension                                                                                                                                                                                                           |
|                                  | 4 mg/kg IV <sup>48</sup>                                                                                                                | 1 mg protamine will neutralize 115 U porcine intestine or 90 U beef lung heparin; may cause hypotension, bradycardia, dyspnea, anaphylaxis; monitor activated partial thromboplastin time and activated clotting time |
| Pyridoxine                       | 3.5 mg/kg in feed <sup>54</sup>                                                                                                         | Supplement during isoniazid therapy                                                                                                                                                                                   |
| Ranitidine                       | 0.5 mg/kg PO q12h <sup>18</sup>                                                                                                         | Anti-ulcerogenic; H <sub>2</sub> receptor antagonist                                                                                                                                                                  |
| Sucralfate                       | 0.5 g/animal PO; maintenance q12h, active ulcer q6h × 4-6 wk <sup>3</sup>                                                               | Most species/prevent or treat gastric ulcers                                                                                                                                                                          |
| Sulfasalazine                    | See <a href="#">Table 12-1</a>                                                                                                          | Antibacterial and antiinflammatory properties                                                                                                                                                                         |
| Tolbutamine                      | 250 mg/animal q24h, then 100 mg/animal q48h <sup>49,139</sup>                                                                           | Capuchin monkeys/oral hypoglycemic agent; non-insulin dependent diabetes mellitus                                                                                                                                     |
| Triamcinolone                    | 0.2-2 mg/kg IM q3d prn <sup>105</sup>                                                                                                   |                                                                                                                                                                                                                       |
| Trimeprazine (Temaril P, Pfizer) | 1-2 mg/kg PO q6h <sup>67</sup>                                                                                                          | Antihistamine                                                                                                                                                                                                         |
| Tryptophan                       | 100 mg/animal PO q12h <sup>141</sup>                                                                                                    | Macaques/self-injurious behavior; add to flavored commercial primate treat                                                                                                                                            |
| Vitamin C (ascorbic acid)        | —                                                                                                                                       | Vitamin C deficiency                                                                                                                                                                                                  |
|                                  | 4-10 mg/kg PO q24h <sup>65</sup>                                                                                                        |                                                                                                                                                                                                                       |
|                                  | 4-25 mg/kg PO q24h <sup>3</sup>                                                                                                         | Chimpanzees                                                                                                                                                                                                           |
|                                  | 25 mg/kg IM q12h × 5 days <sup>114</sup>                                                                                                | Macaques                                                                                                                                                                                                              |
|                                  | 30 mg/kg IM q24h <sup>3</sup>                                                                                                           |                                                                                                                                                                                                                       |
|                                  | 30-100 mg/kg PO q24h <sup>27</sup>                                                                                                      | Macaques (young)                                                                                                                                                                                                      |
| Vitamin D <sub>3</sub>           | 20 U/kg PO q24h <sup>3</sup>                                                                                                            | Chimpanzees                                                                                                                                                                                                           |
|                                  | 250 U/animal PO q24h <sup>135</sup>                                                                                                     | Marmosets/daily requirement for animals housed in indoor exhibits without access to ultraviolet light                                                                                                                 |
|                                  | 2000 U/kg in feed q24h <sup>65</sup>                                                                                                    |                                                                                                                                                                                                                       |
|                                  | 5000 U ergocalciferol depot (sesame oil) IM once at age 4 mo and ergocalciferol 400 U PO q24h from age 4 mo until weaning <sup>71</sup> | Chimpanzees (infants), orangutans (infants)/prevention of rickets; monitor clinical signs, radiographic signs, and serum levels of 25(OH) vitamin D <sub>3</sub>                                                      |
|                                  | 5000 U ergocalciferol depot IM once and ergocalciferol 400 U PO                                                                         | Chimpanzees (infants), orangutans (infants)/treatment of rickets; monitor clinical                                                                                                                                    |

|                            |                                                                                |                                                                              |
|----------------------------|--------------------------------------------------------------------------------|------------------------------------------------------------------------------|
|                            | q24h until resolution of clinical and radiographic abnormalities <sup>71</sup> | signs, radiographic signs, and serum levels of 25(OH) vitamin D <sub>3</sub> |
| Vitamin E (E)/selenium (S) | (E) 3.75 U/kg + (S) 1.15 mg/kg IM q3d × 30 days <sup>120</sup>                 | (E)/(S) responsive myopathy, neuropathy                                      |
| Vitamin K <sub>1</sub>     | 1 mg/kg PO, IM q8h <sup>3</sup>                                                | Chimpanzees                                                                  |
|                            | 1-5 mg/animal IM q24h <sup>3</sup>                                             |                                                                              |
| Zinc                       | 2.5 µg/animal PO q24h × 3 days <sup>3</sup>                                    |                                                                              |

TABLE 12-5 Hematologic and Serum Biochemical Values of Primates.<sup>65</sup>

| Measurement                     | Baboon ( <i>Papio spp</i> ) | Capuchin Monkey ( <i>Cebus sp</i> ) | Chimpanzee ( <i>Pan troglodytes</i> ) | Common Marmoset ( <i>Callithrix sp</i> ) | Lemur ( <i>Lemur spp</i> ) |
|---------------------------------|-----------------------------|-------------------------------------|---------------------------------------|------------------------------------------|----------------------------|
| Hematology                      |                             |                                     |                                       |                                          |                            |
| PCV (%)                         | 44.7                        | 45-53                               | 39.7-44.1                             | 45-48                                    | 48-53                      |
| RBC (10 <sup>6</sup> /µL)       | 4.5-4.8                     | 6                                   | 5.03-6.05                             | 6.9                                      | 6.2-9.8                    |
| Hgb (g/dL)                      | 13                          | 14-17                               | 12.5-14.5                             | 15.1-15.5                                | 15.6-20.2                  |
| WBC (10 <sup>3</sup> /µL)       | 14.1                        | 5-24                                | 7.4-17.6                              | 7-12                                     | 6.2-16.9                   |
| Neutrophils (%)                 | 60.5                        | 55                                  | 37.4-66.6                             | 28-55                                    | 14-40                      |
| Lymphocytes (%)                 | 36                          | 41                                  | 29-57                                 | 43-67                                    | 49-81                      |
| Monocytes (%)                   | 1.5                         | 1.8                                 | 0-2.3                                 | 0.4-2.1                                  | 4                          |
| Eosinophils (%)                 | 1.5                         | 1.6                                 | 0-5.8                                 | 0.5-0.6                                  | 0-4                        |
| Basophils (%)                   | 0.4                         | <1                                  | 0-0.7                                 | 0.3-1.3                                  | <1                         |
| Platelets (10 <sup>3</sup> /µL) | 406                         | 108-187                             | 216-482                               | 390-490                                  | —                          |
| Chemistries                     |                             |                                     |                                       |                                          |                            |
| ALT (U/L)                       | 12-20                       | —                                   | 1.4-10                                | 9.5-10.2                                 | 54.6                       |
| AST (U/L)                       | 22-28                       | —                                   | 4-13.4                                | 160-182                                  | 20.3                       |
| Bilirubin (mg/dL)               | 0.3-0.4                     | —                                   | 0.06-0.28                             | 0.5-0.6                                  | —                          |

|                                 |                                             |                                        |                                                |                                    |         |
|---------------------------------|---------------------------------------------|----------------------------------------|------------------------------------------------|------------------------------------|---------|
| BUN (mg/dL)                     | 8-14                                        | 24-44                                  | 9-19                                           | 27                                 | 18.1    |
| Calcium (mg/dL)                 | 8-10                                        | 10                                     | 8-10                                           | 9.5-10.2                           | 10-12.3 |
| Cholesterol (mg/dL)             | 60-134                                      | 170-254                                | 161-257                                        | 53-248                             | —       |
| Glucose (mg/dL)                 | 80-95                                       | 44-94                                  | 62-94                                          | 126-150                            | —       |
| LDH (U/L)                       | 244-1100                                    | —                                      | —                                              | 799                                | 180-210 |
| Phosphorus (mg/dL)              | 5.5-8.5                                     | 7                                      | 3.6-6                                          | 1.6-10.4                           | 4.3-7.6 |
| Protein, total (g/dL)           | 6-7                                         | 7.5-8.7                                | 6.7-8.1                                        | 7                                  | 7.8     |
| Measurement                     | Rhesus Macaque<br>( <i>Macaca mulatta</i> ) | Spider Monkey<br>( <i>Ateles spp</i> ) | Squirrel Monkey<br>( <i>Saimiri sciureus</i> ) | Tamarin<br>( <i>Saguinus spp</i> ) |         |
| Hematology                      |                                             |                                        |                                                |                                    |         |
| PCV (%)                         | 39-43                                       | 35-40                                  | 43-56                                          | 45                                 |         |
| RBC (10 <sup>6</sup> /μL)       | 4.5-6                                       | 5.5                                    | 7.1-10.9                                       | 6.6                                |         |
| Hgb (g/dL)                      | 12.7                                        | 16                                     | 12.9-17                                        | 15.5                               |         |
| WBC (10 <sup>3</sup> /μL)       | 11.5-12.4                                   | 10-12                                  | 5.1-10.9                                       | 12.6-14.4                          |         |
| Neutrophils (%)                 | 20-56                                       | 52                                     | 36-66                                          | 43-64                              |         |
| Lymphocytes (%)                 | 40-76                                       | 40                                     | 27-55                                          | 34-49                              |         |
| Monocytes (%)                   | 0-2                                         | 3                                      | 0-6                                            | 2-5                                |         |
| Eosinophils (%)                 | 1-3                                         | 5                                      | 0-11                                           | 1-1.2                              |         |
| Continued                       |                                             |                                        |                                                |                                    |         |
| Measurement                     | Rhesus Macaque<br>( <i>Macaca mulatta</i> ) | Spider Monkey<br>( <i>Ateles spp</i> ) | Squirrel Monkey<br>( <i>Saimiri sciureus</i> ) | Tamarin<br>( <i>Saguinus spp</i> ) |         |
| Basophils (%)                   | 0-1                                         | 0-1                                    | <1                                             | 0.1                                |         |
| Platelets (10 <sup>3</sup> /μL) | 130-144                                     | 239-343                                | 112                                            | 331-650                            |         |
| Chemistries                     |                                             |                                        |                                                |                                    |         |
| ALT (U/L)                       | 145-171                                     | —                                      | 59-99                                          | 7-14                               |         |
| AST (U/L)                       | 20-34                                       | —                                      | 56-118                                         | 49-59                              |         |
| Bilirubin (mg/dL)               | 0.10-0.66                                   | —                                      | 0.1-0.53                                       | 0.14-0.26                          |         |
| BUN (mg/dL)                     | 14.2-19.6                                   | 25.9                                   | 23-39                                          | 6-12                               |         |
| Calcium (mg/dL)                 | 8.1-11.3                                    | 12.8                                   | 8.3-9.7                                        | 10                                 |         |
| Cholesterol (mg/dL)             | 94-162                                      | —                                      | 127-207                                        | 69                                 |         |
| Glucose (mg/dL)                 | 53-87                                       | 82.3                                   | 52-108                                         | 125-189                            |         |
| LDH (U/L)                       | 201-665                                     | —                                      | 271-490                                        | —                                  |         |
| Phosphorus (mg/dL)              | 4-6                                         | —                                      | 3.3-7.7                                        | 3-6                                |         |
| Protein, total (g/dL)           | 6.1-7.1                                     | 10.2                                   | 6.9-8.1                                        | 6.2-8.6                            |         |

TABLE 12-6 Biologic and Physiologic Data of Primates.<sup>65</sup>



| Species                                     | Temperature<br>°C (°F)  | Respiratory<br>(breaths/min) | Heart Rate<br>(beats/min) | Avg wt.<br>(kg) M/F | Estrus Length<br>(days) | Gestation<br>(days) | Weaning<br>Age (days) | Life Span<br>(max; yr) |
|---------------------------------------------|-------------------------|------------------------------|---------------------------|---------------------|-------------------------|---------------------|-----------------------|------------------------|
| Baboon ( <i>Papio</i> sp)                   | 36-39 (96.8-102.2)      | 29                           | 80-200                    | 21/12-15            | 31                      | 175-180             | 180-456               | 40-45                  |
| Capuchin monkey ( <i>Cebus</i> sp)          | 37-38.5 (98.6-101.3)    | 30-50                        | 165-225                   | 3.8/2.7             | 16-20                   | 160                 | 270                   | 46                     |
| Chimpanzee ( <i>Pan troglodytes</i> )       | 35.5-37.8 (95.9-100)    | 35-60                        | 80-150                    | 42/31               | 36                      | 228                 | 547-1460              | ≥53                    |
| Common marmoset ( <i>Callithrix</i> sp)     | 35.4-39.7 (95.7-103.5)  | 20-50                        | 240-350                   | 0.31/0.29           | 16                      | 148                 | 60-180                | 12                     |
| Lemur ( <i>Lemur</i> sp)                    | 37.9-38.1 (100.2-100.6) | —                            | 168-210                   | 2.9/2.5             | 39                      | 135                 | 105                   | 27                     |
| Rhesus macaque ( <i>Macaca mulatta</i> )    | 36-40 (96.8-104)        | 10-25                        | 150-333                   | 6.2/3               | 28                      | 167                 | 210-425               | 30                     |
| Spider monkey ( <i>Ateles</i> sp)           | 36-39.4 (96.8-102.9)    | 18-30                        | 160-210                   | 6.2/5.8             | 26                      | 229                 | 365                   | 20                     |
| Squirrel monkey ( <i>Saimiri sciureus</i> ) | 33.5-38.8 (92.3-101.8)  | 20-50                        | 225-350                   | 0.75/0.58           | 18                      | 170                 | 182                   | 20                     |
| Tamarin ( <i>Saguinus</i> sp)               | 39.3-40.1 (102.7-104.2) | —                            | —                         | 0.45/0.51           | 16                      | 145                 | 60-90                 | 13                     |

TABLE 12-7 Preventive Medicine Recommendations for Primates.[65,68,106](#)

| Procedure                                                              | Schedule                                               | Comments                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
|------------------------------------------------------------------------|--------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Physical examination                                                   | Annually                                               | Includes CBC, serum biochemical analysis, dental prophylaxis, serum banking, serology, etc.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
| Tuberculin skin testing (Intradermal Mammalian Tuberculin, Synbiotics) | 0.1 mL ID via 25-27 ga needle; test annually           | Old World primates, great apes/tests are read at 24, 48, and 72 hr; a positive reaction is erythema and/or induration/edema persisting for >48 hr; tuberculin products with at least 1500 U per test dose are recommended (Mammalin Old Tuberculin—OT); intrapalpebral test site can be examined without restraint; alternate sites include the abdomen, thorax, antebrachium; newly arrived primates undergo a 90-day quarantine with tuberculosis test q14d × 3 treatments; surveillance of established primates includes testing q3mo and if they are in contact with humans whose tuberculosis status is unknown; tuberculin testing of primates and staff in contact with primates should be performed annually in closed colonies; false positives (especially in orangutans) and false negatives (anergic animals) can occur; refer to recommendations in references if a positive reaction is obtained <a href="#">115</a> |
|                                                                        | 0.05 mL ID via 28 ga needle; test annually             | New World primates/same readings and recommendations for Old World primates, great apes; newly arrived primates undergo 90-day quarantine with tuberculosis test q14d × 3 treatments; surveillance of established primates varies between facilities from quarterly to annually depending on the research goals, value of the colony and potential for exposure <a href="#">17,89</a>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
| Whole-blood interferon gamma immunoassay testing (Primagam)            | 1-2 mL of whole blood in parallel with tuberculin skin | During quarantine period, 2 tests are recommended at the start and the end of the quarantine period for an optimal diagnostic coverage; can be used for gorillas, chimpanzees, orangutans, gibbons, colobids, baboons, mandrills, macaques, vervets, guenons, squirrel monkeys, langurs and marmosets; may not be reliable in cynomolgus macaques; <a href="#">17,84</a> tuberculin skin test and Primagam test used in parallel provide the best sensitivity and specificity                                                                                                                                                                                                                                                                                                                                                                                                                                                      |

|                            |                          |                                                                                                                                                                                                                                                                                                      |
|----------------------------|--------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                            | testing                  | profile for the detection of tuberculosis in nonhuman primates <sup><a href="#">41,124</a></sup>                                                                                                                                                                                                     |
| Fecal parasite examination | q3-12mo                  | Direct wet mount of fresh feces for protozoa; flotation and/or sedimentation procedures for parasite ova; trichrome stains can be used to identify protozoal cysts; several institutions use prophylactic ivermectin treatment q4-12mo for outdoor housed animals <sup><a href="#">19</a></sup>      |
| Fecal culture              | Initial screen, then prn | Culture for <i>Salmonella</i> , <i>Shigella</i> , <i>Campylobacter</i> , <i>Yersinia</i> ; may take ≥3 samples to identify carriers of <i>Salmonella</i> or <i>Shigella</i> ; can be asymptomatic carriers; stain direct fecal smears to identify WBCs and RBCs if infectious enteritis is suspected |

TABLE 12-8 Immunization Recommendations for Primates.<sup>a</sup>

| Species            | Immunization | Dose/Schedule                                                                                                                                            | Comments                                                                                                                                                                                                                                                                                                                                       |
|--------------------|--------------|----------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Prosimians         |              |                                                                                                                                                          | There are no specific recommendations for prosimians <sup>2</sup>                                                                                                                                                                                                                                                                              |
|                    | Rabies       |                                                                                                                                                          | Killed vaccine only; used in some institutions based on local rabies epidemiology status <sup>2</sup>                                                                                                                                                                                                                                          |
|                    | Tetanus      | Tetanus toxoid                                                                                                                                           | Used in some institutions <sup>2</sup>                                                                                                                                                                                                                                                                                                         |
| New World primates | Measles      | Human attenuated vaccine (Attenuvax, Merck), 0.25 mL SC, 6 mo of age <sup>19,89</sup>                                                                    | Measles in New World primates is a severe disease that may be associated with epizootics of high morbidity and mortality; in callitrichids, the virus targets the gastrointestinal tract; <sup>89</sup> not available in the United States; although an attenuated measles/mumps/rubella vaccine is available, it is rarely recommended        |
|                    | Rabies       | 1 mL dose of killed vaccine IM (quadriceps muscle) days 2,7,12,19,33 post exposure and single dose of human rabies immunoglobulin IM 5 days postexposure | Capuchin monkeys/postexposure prophylaxis in monkeys that had direct contact with rabid bats; animals developed and maintained levels of rabies virus neutralizing antibody >0.05 U/mL by 67 days postexposure; <sup>76</sup> not sanctioned by the AVMA; used by some institutions in rabies-endemic areas; use only killed virus preparation |
|                    | Tetanus      | Human tetanus toxoid, 2,4,6,18 mo of age, then 4-6 yr and 14-16 yr of age, then booster q10yr <sup>65,86</sup>                                           | New World monkeys are susceptible to <i>Clostridium tetani</i> ; vaccination is recommended for outdoor housed animals; <sup>127</sup> the triple vaccine (diphtheria, tetanus, and pertussis) should not be used (a large number of adverse reactions have been reported) <sup>136</sup>                                                      |
| Old World primates | Measles      | Human attenuated vaccine (Attenuvax, Merck) 6 mo of age, then booster in 5-7 mo <sup>68</sup>                                                            | Distemper-Measles <sup>22</sup> vaccine (Vanguard V) is no longer available; Attenuvax is not available in the United States                                                                                                                                                                                                                   |
|                    | Rabies       | 1 yr of age, booster q3yr <sup>12</sup>                                                                                                                  | Use only killed virus preparation <sup>12</sup>                                                                                                                                                                                                                                                                                                |
|                    | Tetanus      | Equine tetanus toxoid vaccine; 6 mo of age, booster at 18 mo of age, then q5yr <sup>19</sup>                                                             | Recommended only for outdoor housed animals <sup>19,128</sup>                                                                                                                                                                                                                                                                                  |

Continued

| Species    | Immunization | Dose/Schedule                                                                            | Comments                                                                                                                                                |
|------------|--------------|------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------|
| Great apes | Measles      | Human attenuated vaccine (Attenuvax, Merck)                                              | Optional; risk of shedding live virus and susceptibility of pregnant females and fetus is unquantified; <sup>1</sup> not available in the United States |
|            | Polio        | Modified-live oral vaccine (OPV) once <sup>100</sup>                                     | Persistence of neutralizing antibodies for at least 9 yr postvaccination <sup>100</sup>                                                                 |
|            |              | 2,4,18 mo of age then 4-6 yr and 14-16 yr of age <sup>65,86</sup>                        | Based on human schedule; follow current human pediatric recommendation for route and frequency                                                          |
|            | Rabies       | 1 mL IM at 2 yr of age, then q1-3yr <sup>1,12</sup>                                      | Use only killed virus preparations; based on local rabies epidemiology and status <sup>1,12</sup>                                                       |
|            | Tetanus      | 1 mL IM of tetanus toxoid, 1 yr of age, then q5yr or q1-10yr <sup>1,12</sup>             | The triple vaccine (diphtheria, tetanus, and pertussis) should not be used (a large number of adverse reactions have been reported) <sup>135</sup>      |
|            |              | 2,4,6,18 mo of age, then 4-6 yr and 14-16 yr of age, then booster q10yr <sup>65,86</sup> | Based on human schedule                                                                                                                                 |
|            | Pneumococcal | Once in childhood, with a geriatric booster for bonobos and orangutans <sup>1</sup>      |                                                                                                                                                         |
|            | Influenza    | Annually <sup>1</sup>                                                                    | Bonobos; early fall prior to influenza season <sup>1</sup>                                                                                              |

<sup>a</sup>All vaccination protocols should be based on a risk/benefits assessment: level of exposure, indoor/outdoor housing, and research design.

TABLE 12-9 Non-human Primate Laboratories.

| Laboratory                                                                                                                                                   | Services          |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------|
| <p>Analytics Incorporated</p> <p>200 Girard Street, Suite 200</p> <p>Gaithersburg, MD 20877, USA</p> <p>Telephone: 301-921-0168</p> <p>Fax: 301-977-0433</p> | Special chemistry |
| BioReliance Corp Simian Diagnostic Laboratory                                                                                                                |                   |

|                                                                                                                                                                                                                                                                                                              |                                                                                                                                                                                                                                                                  |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <p>14920 Broschart Road</p> <p>Rockville, MD 20850, USA</p> <p>Telephone: 301-738-1000</p> <p>800-804-3586</p> <p>Fax: 301-610-2590</p> <p>E-mail:<br/> <a href="mailto:info@bioreliance.com">info@bioreliance.com</a></p> <p>Website:<br/> <a href="http://www.bioreliance.com">www.bioreliance.com</a></p> | <p>Filovirus screening; macaque antibody panel (herpes B, SIV, SRV, STLV-1); African species antibody panel (SA8, SA11, SIV, STLV-1); baboon antibody panel (HVP2, SA11, SIV, STLV-1); retrovirus antibody panel (foamy virus, SIV, SRV, STLV-1); monkey pox</p> |
| <p>California National Primate Research Center (CNPRC)</p> <p>University of California</p> <p>1 Shields Ave</p> <p>Davis, CA 95616, USA</p> <p>Telephone: 530-752-0447</p> <p>Website:<br/> <a href="http://www.primate.ucdavis.edu">www.primate.ucdavis.edu</a></p>                                         | <p>Hormonal and immunological assays, flow cytometry services, routine clinical laboratory testing</p>                                                                                                                                                           |
| <p>Cornell University</p> <p>Animal Health Diagnostic Center</p> <p>Upper Tower Road</p> <p>Ithaca, NY 14853, USA</p> <p>Telephone: 607-275-0622</p> <p>Fax: 607-275-0720</p> <p>Website:<br/> <a href="http://www.ahdc.vet.cornell.edu">www.ahdc.vet.cornell.edu</a></p>                                    | <p>Comparative coagulation panel</p>                                                                                                                                                                                                                             |

|                                                                                                                                                                                                                                                                                         |                                                                                                                                   |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------|
| <p>Esoterix Clinical Trial Services</p> <p>A division of LabCorp (see below)</p> <p>Telephone: 908-709-5725</p> <p>Fax: 908-709-5791</p>                                                                                                                                                | <p>Miscellaneous laboratory testing</p>                                                                                           |
| <p>LabCorp</p> <p>1904 Alexander Drive</p> <p>RTP, NC 27709, USA</p> <p>Telephone: 800-533-0567</p> <p>Website: <a href="http://www.labcorp.com">www.labcorp.com</a></p>                                                                                                                | <p>Miscellaneous laboratory testing, special chemistry panel</p>                                                                  |
| <p>National B Virus Resource Center</p> <p>Viral Immunology Center</p> <p>Georgia State University</p> <p>50 Decatur Street</p> <p>Atlanta, GA 30303, USA</p> <p>Telephone: 404-413-6550</p> <p>Fax: 404-413-6556</p> <p>E-mail: <a href="mailto:bvirus@gsu.edu">bvirus@gsu.edu</a></p> | <p>Cercopithecine herpesvirus 1 (herpes B)</p>                                                                                    |
| <p>Pathogen Detection Laboratory</p> <p>University of California, Davis</p> <p>Road 98 &amp; Hutchinson</p>                                                                                                                                                                             | <p>Laboratory testing, consultation, and interpretation of the following viral agents: simian retrovirus type D (SRV), simian</p> |

|                                                                                                                                                                                                                          |                                                                                                                                    |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------|
| <p>Davis, CA 95616, USA</p> <p>Telephone: 530-752-8242</p> <p>Fax: 530-752-4816</p> <p>Website:<br/> <a href="http://srl.primate.ucdavis.edu">http://srl.primate.ucdavis.edu</a></p>                                     | <p>immunodeficiency virus (SIV), simian T-cell lymphotropic virus (STLV), simian foamy virus (SFV), RhCMV, RRV, Primagam, SV40</p> |
| <p>Penn State College of Agricultural Sciences</p> <p><i>E. coli</i> Reference Center</p> <p>104 Wiley Lab, Wiley Lane</p> <p>University Park, PA 16802, USA</p> <p>Telephone: 814-863-2167</p> <p>Fax: 814-865-9895</p> | <p>Pathogenic <i>Escherichia coli</i></p>                                                                                          |
| <p>USDA, APHIS,</p> <p>National Veterinary Services Laboratories</p> <p>PO Box 844</p> <p>1920 Dayton Ave</p> <p>Ames, IA 50010, USA</p> <p>Telephone: 515-337-7266</p>                                                  | <p><i>Mycobacterium</i> testing and isolation (PCR, culture, AFB smear)</p>                                                        |
| <p>Virus Reference Labs</p> <p>7540 Louis Pasteur, Suite 205</p> <p>San Antonio, TX 78229, USA</p> <p>Telephone: 210-614-7350</p>                                                                                        | <p>Miscellaneous virus detection</p>                                                                                               |

|                                                                                                                                                                           |                             |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------|
| Fax: 210-614-7355                                                                                                                                                         |                             |
| Zoologix<br>9811 Owensmouth Avenue,<br>Suite 4<br>Chatsworth, CA 91311, USA<br>Telephone: 818-717-8880<br>Website: <a href="http://www.zoologix.com">www.zoologix.com</a> | Non-human primate PCR assay |

### References

1. American Association of Zoo Veterinarians Web site. Guidelines for Ape, Preventive Health program. Available at [www.aazv.org/displaycommon.cfm?an=1&subarticlenbr=281](http://www.aazv.org/displaycommon.cfm?an=1&subarticlenbr=281), Nov 12, 2010. Accessed
2. American Association of Zoo Veterinarians Web site. Recommended Prosimian Preshipment, Quarantine, and Preventive Medicine Guidelines. Available at [www.aazv.org/displaycommon.cfm?an=1&subarticlenbr=280](http://www.aazv.org/displaycommon.cfm?an=1&subarticlenbr=280), Nov12, 2010. Accessed
3. Association of Primate Veterinarians Website. Primate Formulary. Alamogordo Primate Facility. Available at [www.primatevets.org/pub\\_downloads.aspx](http://www.primatevets.org/pub_downloads.aspx), Nov 9, 2010. Accessed
4. Authier S, Charaud F, Legaspi M, et al. Comparison of three anesthetics protocols for intraduodenal drug administration using endoscopy in rhesus monkeys. *J Am Assoc Lab Anim Sci*. 2006;45:73–79.
5. Badyal DK, Garg SK. Effect of clarithromycin on the pharmacokinetics of carbamazepine in rhesus monkeys. *Methods Find Clin Pharmacol*. 2000;222:581–584.
6. Banish LD, Sims R, Bush M, et al. Clearance of Shigella flexneri carriers in a zoologic collection of primates. *J Am Vet Med Assoc*. 1993;203:133–136.



7. Banknieder AR, Phillips JM, Jackson KT, et al. Comparison of ketamine with the combination of ketamine and xylazine for effective anesthesia in the rhesus monkey (*Macaca mulatta*). *Lab Anim*. 1978;28:196–197.
8. Barrie MT, Stadler CK. Successful treatment of *Cryptococcus neoformans* infection in an Allen's swamp monkey (*Allenopithecus nigroviridis*) using fluconazole and flucytosine. *J Zoo Wildl Med*. 1995;26:109–114.
9. Belmont M, Beemer G, Bownes P, et al. Comparative pharmacology of atracurium and one of its isomers, 51W89, in rhesus macaques. (Abstract). *Anesthesiology*. 1993;79:A947.
10. Bentzel DE, Bacon DJ. Comparison of various anthelmintic therapies for the treatment of *Trypanoxyuris microon* infection in owl monkeys (*Aotus nancymae*). *Comp Med*. 2007;57:206–209.
11. Benveniste H, Fowler JS, Rooney WD, et al. MRI study. Maternal-fetal in vivo imaging. a combined PET and MRI study. *J Nucl Med*. 2003;44:1522–1530.
12. Bernacky BJ, Gibson SV, Keeling ME, et al. Nonhuman primates. In: Fox JG, Anderson LC, Loew FM, et al. *Laboratory Animal Medicine*. 2nd ed. San Diego: Elsevier Science; 2002:676–791.
13. Blackwood RS, Tarara RP, Christe KL, et al. Effects of the macrolide drug tylosin on chronic diarrhea in rhesus macaques (*Macaca mulatta*). *Comp Med*. 2008;58:81–87.
14. Bohm RP, Jr., Dennis V, Blanchard JL, et al. Clinical outcome of a protocol to produce immunosuppression in rhesus monkeys (*Macaca mulatta*). application to infectious disease and gene therapy studies. *J Med Primatol*. 1999;28:344–352.
15. Bohm RP, Jr., Rockar RA, Ratterree MS, et al. A method of video-assisted thoracoscopic surgery for collection of thymic biopsies in rhesus monkeys (*Macaca mulatta*). *Contemp Top Lab Anim Sci*. 2000;39:24–26.
16. Booker JL, Erickson HH, Fitzpatrick EL. Cardiodynamics in the rhesus macaque during dissociative anesthesia. *Am J Vet Res*. 1982;43:671–676.

17. Bushmitz M, Lecu A, Verreck F, et al. Guidelines for the prevention and control of tuberculosis in non-human primates. recommendations of the European Primate Veterinary Association working group on tuberculosis. *J Med Primatol*. 2009;38:59–69.
18. California National Primate Research Center. California National Primate Research Center Formulary. Davis: University of California; (no date).
19. California National Primate Research Center. *Veterinary Pharmaceutical Formulary and Clinical Reference Handbook*. Davis: University of California; 2009.
20. Canadian Council on Animal Care. *Guide to the Care and Use of Experimental Animals. Vol I, II*. Ontario: Canadian Council on Animal Care; 1984.
21. Capuano SV, Lerche NW, Valverde CR. Cardiovascular, respiratory, thermoregulatory, sedative, and analgesic effects of intravenous administration of medetomidine in rhesus macaques (*Macaca mulatta*). *Lab Anim Sci*. 1999;49:537–544.
22. Christe KL, McChesney MB, Spinner A, et al. Comparative efficacy of a canine distemper-measles and a standard measles vaccine for immunization of rhesus macaques (*Macaca mulatta*). *Comp Med*. 2002;52:467–472.
23. Cohen BJ, Bree MM. Chemical and physical restraint of nonhuman primates. *J Med Primatol*. 1978;7:193–201.
24. Cookson JH, Mills FJ. Continuous infusion anaesthesia in baboons with alphaxolone-alphadolone. *Lab Anim*. 1983;17:196–197.
25. Dubois A, Berg DE, Fiala N, et al. Cure of *Helicobacter pylori* infection by omeprazole-clarithromycin-based therapy in nonhuman primates. *J Gastroenterol*. 1998;33:18–22.
26. Eberhard ML. Chemotherapy of filariasis in squirrel monkeys (*Saimiri sciureus*). *Lab Anim Sci*. 1982;32:397–400.
27. Eisele PH, Morgan JP, Line AS, et al. Skeletal lesions and anemia associated

with ascorbic acid deficiency in juvenile rhesus monkeys. *Lab Anim Sci*. 1992;42:245–249.

28. Fanton JW, Zar SR, Ewert DL, et al. Cardiovascular responses to propofol and etomidate in long-term instrumented rhesus macaques (*Macaca mulatta*). *Comp Med*. 2000;5:303–308.

29. Feeser P, White F. Medical management of *Lemur catta*, *Varecia variegata*, and *Propithecus verreauxi* in natural habitat enclosures. *Proc Annu Conf Am Assoc Zoo Vet/Am Assoc Wildl Vet*; 1992:320–323.

30. Field WE, Yelnosky J, Mundy J, et al. Use of droperidol and fentanyl for analgesia and sedation of primates. *J Am Vet Med Assoc*. 1966;149:896–901.

31. Flecknell P. Clinical experience with NSAIDs in macaques. *Lab Primate Newsl*. 2005;44:4.

32. Flecknell PA. *Laboratory Animal Anaesthesia*. London: Academic Press; 1987.

33. Flecknell PA. *Laboratory Animal Anaesthesia*, 2nd ed. London: Academic Press; 1996.

34. Flecknell PA. *Laboratory Animal Anaesthesia*, 3rd ed. Boston: Elsevier/Academic Press; 2009.

35. Foltin RW. Getting cynomolgus to take their medicine. *Lab Primate Newsl*. 1997;36:4–5.

36. Fortman JD, Hewett TA, Bennett BT. *The Laboratory Nonhuman Primate*. Boca Raton, FL: CRC Press, 2002.

37. Foster A, Zeller W, Pfannkuch H. Effect of thiopental, saffan, and propofol anesthesia on cardiovascular parameters and bronchial smooth muscle in the rhesus monkey. *Lab Anim Sci*. 1996;46:327–334.

38. Fowler KA, Huerkamp MJ, Pullium JK, et al. Anesthetic protocol. propofol use in rhesus macaques (*Macaca mulatta*) during magnetic resonance imaging with

stereotactic head frame application. *Brain Res Brain Res Protoc*. 2001;7:87–93.

39. Fraser CM, Bergeron JA, Mays A, et al. Diseases of nonhuman primates. In: *The Merck Veterinary Manual*. 7th ed. Rathway, NJ: Merck & Co; 1991:1032–1036.

40. Furtado MM, Nunes AL, Intelizano TR, et al. Comparison of racemic ketamine versus (S+) ketamine when combined with midazolam for anesthesia of *Callithrix jacchus* and *Callithrix penicillata*. *J Zoo Wildl Med*. 2010;41:389–394.

41. Garcia MA, Yee J, Bouley DM, et al. Diagnosis of tuberculosis in macaques, using whole-blood in vitro interferon-gamma (Primagam) testing. *Comp Med*. 2004;54:86–92.

42. Gilardi KVK, Valverde CR. Glucose control with glipizide therapy in a diabetic dusky titi monkey (*Callicebus moloch*). *J Zoo Wildl Med*. 1995;26:82–86.

43. Gilfillan EC, Pelak BA, Bland JA, et al. Pharmacokinetic studies of norfloxacin in laboratory animals. *Chemotherapy*. 1984;30:288–296.

44. Glen JB. Animal studies of the anaesthetic activity of ICI 35 868. *Br J Anaesth*. 1980;52:731–742.

45. Golub MS, Germann SL. Perinatal bupivacaine and infant behavior in rhesus monkeys. *Neurotoxicol Terat*. 1998;20:29–41.

46. Gracenea M, Gomez MS, Fernandez J, et al. Secnidazole vs. paromomycin. comparative antiprotozoan treatment in captive monkeys. *J Med Primatol*. 1998;27:38–43.

47. Graybill JR, Griffith L, Sun SH. Fluconazole therapy for coccidioidomycosis in Japanese macaques. *Rev Infect Dis*. 1990;12(Suppl3):S286–290.

48. Greenberg MJ, Janssen DL, Jamieson SW, et al. Surgical repair of an atrial septal defect in a juvenile Sumatran orangutan (*Pongo pygmaeus sumatraensis*). *J Zoo Wildl Med*. 1999;30:256–261.

49. Greenwood AG, Taylor DC. Control of diabetes in a capuchin monkey with tolbutamide. *Vet Rec.* 1977;101:407–408.
50. Hawk CT, Leary SL. Formulary for Laboratory Animals. Ames: Iowa State University Press, 1995.
51. Hawk CT, Leary SL. Formulary for Laboratory Animals, 2nd ed, Ames: Iowa State University Press, 1999.
52. Heard DJ. Principles and techniques of anesthesia and analgesia for exotic practice. *Vet Clin North Am Small Anim Pract.* 1993;23:1301–1327.
53. Hilton K, Hasselschwert D, Handt L, et al. A pharmacokinetics study of enrofloxacin and its active metabolite ciprofloxacin after oral and intramuscular dosing of enrofloxacin in rhesus monkeys (*Macaca mulatta*). *J Med Primatol.* 2008;37:177–183.
54. Holmes DD. *Clinical Laboratory Animal Medicine*. Ames: Iowa State University Press; 1984.
55. Horne WA. Primate anesthesia. *Vet Clin North Am Exotic Anim Pract.* 2001;24:239–266.
56. Horne WA, Wolfe BA, Norton TM, et al. Comparison of the cardiopulmonary effects of medetomidine-ketamine and medetomidine-Telazol induction on maintenance isoflurane anesthesia in the chimpanzee. *Proc Annu Conf Am Assoc Zoo Vet*; 1998:22–25.
57. Hotchkiss CE. Use of cisapride for the treatment of intestinal pseudo-obstruction in a stump-tail macaque (*Macaca arctoides*). *J Zoo Wildl Med.* 1995;26:98–101.
58. Hrapkiewicz K, Medina L. Nonhuman primates. In: *Clinical Laboratory Animal Medicine*. 3rd ed. Ames: Blackwell Publishing; 2007:280–329.
59. Ialeggio DM. Practical medicine of primate pets. *Compend Cont Educ Pract Vet.* 1989;11:1252–1258.

60. Institutional Animal Care and Use Committee of the University of California San Francisco. Nonhuman Primate Formulary. Anesthesia and Analgesia in Laboratory Animals at UCSF. Available at <http://www.iacuc.ucsf.edu/Proc/awNHPFrm.asp>, Jan 18, 2011. Accessed
61. Isaza R, Baker B, Dunker F. Medical management of inflammatory bowel disease in a spider monkey. *J Am Vet Med Assoc*. 1992;200:1543.
62. Jacobs B, Harris GC, Allada V, et al. Midazolam as an effective intravenous adjuvant to prolonged ketamine sedation in young rhesus (*Macaca mulatta*) and vervet (*Cercopithecus aethiops sabaeus*) monkeys. a preliminary report. *J Med Primatol*. 1993;29:291–298.
63. James SB, Raphael BL. Demodicosis in red-handed tamarins (*Saguinus midas*). *J Zoo Wildl Med*. 2000;31:251–254.
64. James SB, Calle PP, Raphael BL, et al. A survey for fecal *Clostridium perfringens* and *C. difficile* toxins in primate feces at the Wildlife Conservation Park/Bronx Zoo. *Proc Annu Conf Am Assoc Zoo Vet*; 1998:119–121.
65. Johnson-Delaney CA. Primates. *Vet Clin North Am Small Anim Pract*. 1994;24:121–156.
66. Johnson-Delaney CA. Parasites of captive nonhuman primates. *Vet Clin North Am Exotic Animal Pract*. 2009;12:563–581.
67. Johnson DK, Russell RJ, Stunkard JA. *A Guide to Diagnosis, Treatment and Husbandry of Nonhuman Primates*. Edwardsville, KS: Veterinary Medicine Publishing Co; 1981.
68. Junge RE. *Preventative medicine recommendations*. Philadelphia: American Association of Zoo Veterinarians Infectious Disease Committee; 1991.
69. Junge RE. Diseases of prosimians. Fowler ME, Miller RE. *Zoo and Wild Animal Medicine. Current Therapy 4*. Philadelphia: WB Saunders Co; 1999:365–368.
70. Junge RE. Prosimians. In: Fowler ME, Miller RE. *Zoo and Wild Animal*

*Medicine*. 5th ed. Philadelphia: WB Saunders Co; 2003:334–346.

71. Junge RE, Gannon FH, Porton I, et al. Management and prevention of vitamin D deficiency rickets in captive-born juvenile chimpanzees (*Pan troglodytes*). *J Zoo Wildl Med*. 2000;31:361–369.
72. Junge RE, Mehren KG, Meehan TP, et al. Periarticular hyperostosis and renal disease in six black lemurs of two family groups. *J Am Vet Med Assoc*. 1994;205:1024–1029.
73. Kalter SS, Millstein CH, Boncyk LH, et al. Tuberculosis in nonhuman primates as a threat to humans. *Dev Biol Stand*. 1978;41:85–91.
74. Kearns KS, Swenson B, Ramsay EC. Oral induction of anesthesia with droperidol and transmucosal carfentanil citrate in chimpanzees (*Pan troglodytes*). *J Zoo Wildl Med*. 2000;31:185–189.
75. Kelly DJ, Chulay JD, Mikesell P, et al. Serum concentrations of penicillin, doxycycline, and ciprofloxacin during prolonged therapy in rhesus monkeys. *J Infect Dis*. 1992;166:1184–1187.
76. Kenny DE, Knightly F, Baier J, et al. Exposure of hooded capuchin monkeys (*Cebus apella* cay) to a rabid bat at a zoological park. *J Zoo Wildl Med*. 2001;32:123–126.
77. Lafortune M, Wellehan JF, Jacobson ER, et al. Proliferative enteritis associated with *Lawsonia intracellularis* in a Japanese macaque (*Macaca fuscata*). *J Zoo Wildl Med*. 2004;35:549–552.
78. Lair S, Cranshaw GJ, Mehren KG, et al. Diagnosis of hypothyroidism in a Western lowland gorilla (*Gorilla gorilla gorilla*) using human thyroid-stimulating hormone assay. *J Zoo Wildl Med*. 1999;30:537–540.
79. Lamberski N. Hypothyroidism in white-faced saki monkeys (*Pithecia pithecia*). *Proc North Am Vet Conf*; 1998:876.
80. Langan GP, Harvey RC, O'Rourke D, et al. Cardiopulmonary effects of sevoflurane in Garnett's greater bush baby (*Otolemur garnettii*). *Comp Med*.

81. Laudenslager ML, Clarke AS. Antidepressant treatment during social challenge prior to 1 year of age affects immune and endocrine responses in adult macaques. *Psych Res*. 2000;95:25–34.
82. Lee DR, Guhad FA. Medical management of captive chimpanzees. American Society of Primatologists. In: *The Care and Management of Captive Chimpanzees*. Vol 2. San Antonio: Wiley-Liss; 2001.
83. Lewis JCM. Medetomidine-ketamine anaesthesia in the chimpanzee (*Pan troglodytes*). *J Vet Anaesthesiol*. 1993;20:18–20.
84. Lincoln Park Zoo Web site. Common chimpanzee (*Pan troglodytes*) preventive veterinary program for zoos. Available at [www.lpzoo.org/chimp-ssp/password/SOC\\_chimp.pdf](http://www.lpzoo.org/chimp-ssp/password/SOC_chimp.pdf), Nov 12, 2010. Accessed
85. Line AS, Paul-Murphy J, Aucoin DP, et al. Enrofloxacin treatment of long-tailed macaques with acute bacillary dysentery due to multiresistant *Shigella flexneri* IV. *Lab Anim Sci*. 1992;42:240–244.
86. Loomis MR. Update of vaccination recommendations for nonhuman primates. *Proc Annu Conf Am Assoc Zoo Vet*; 1990:257–260.
87. Loomis MR. Great apes. In: Fowler ME, Miller RE. *Zoo and Wild Animal Medicine*. 5th ed. Philadelphia: WB Saunders Co; 2003:381–397.
88. Lopez KR, Gibbs PH, Reed DS. A comparison of body temperature changes due to the administration of ketamine-acepromazine and tiletamine-zolazepam anesthetics in cynomolgus macaques. *Contemp Top Lab Anim Sci*. 2002;41:47–50.
89. Ludlage E, Mansfield K. Clinical care and diseases of the common marmoset (*Callithrix jacchus*). *Comp Med*. 2003;53:369–382.
90. Macy JD, Beattie TA, Morgenstern SE, et al. Use of guanfacine to control self-injurious behavior in two rhesus macaques (*Macaca mulatta*) and one baboon (*Papio anubis*). *Comp Med*. 2000;50:419–425.



91. Madara JL, Podolsky DK, King NW, et al. Characterization of spontaneous colitis in cotton-top tamarins (*Saguinus oedipus*) and its response to sulfasalazine. *Gastroenterology*. 1985;88:13–19.
92. Mama KR, Valverde CR, Steffey EP, et al. Effect of fentanyl on minimum alveolar concentration of isoflurane in rhesus macaques. (Abstract). *Vet Anaesth Analg*. 2000;27:58.
93. Marks SK. Disease review. balantidiasis. American Association of Zoo Veterinarians Infectious Disease Committee. Philadelphia: American Association of Zoo Veterinarians; 1994.
94. Martin C, Roman V, Agay D, et al. Anti-emetic effect of ondansetron and granisetron after exposure to mixed neutron and gamma irradiation. *Radiat Res*. 1998;149:631–636.
95. Melby EC, Altman NH. CRC Handbook of Laboratory Animal Science. Vol 3. Cleveland: CRC Press, 1976.
96. Michel J-C, de Thoisy B, Contamin H. Chemotherapy of haemobartonellosis in squirrel monkeys (*Saimiri sciureus*). *J Med Primatol*. 2000;29:85–87.
97. Miller CL, Schwartz AM, Barnhart JS, Jr., et al. Chronic hypertension with subsequent congestive heart failure in a Western lowland gorilla (*Gorilla gorilla gorilla*). *J Zoo Wildl Med*. 1999;30:262–267.
98. Montali RJ, Bush M. Diseases of callitrichidae. Fowler ME, ed. Zoo and Wild Animal Medicine. Current Therapy 4. Philadelphia: WB Saunders Co; 1999:369–376.
99. Morris PJ. Clinical update. gastrointestinal disease syndromes in colobinae. Proc North Am Vet Conf; 1996:903–904.
100. Mugisha L, Pauli G, Opuda-Asido J, et al. Evaluation of poliovirus antibody titers in orally vaccinated semi-captive chimpanzees in Uganda. *J Med Primatol*. 2010;39:123–128.
101. Neiffer DL, Klein EC. Interstitial cell tumor in a black-and-white ruffed lemur

(*Varecia variegatus variegatus*). *J Zoo Wildl Med*. 2001;32:260–267.

102. Neiffer DL, Rothschild BM, Marks SK, et al. Management of reactive arthritis in a juvenile gorilla (*Gorilla gorilla gorilla*) with long-term sulfasalazine therapy. *J Zoo Wildl Med*. 2000;31:539–551.

103. Orkin JL. Getting cynomolgus to take their medicine. *Lab Primate Newsl*. 1997;36:4–5.

104. Patton DL, Cosgrove YT, Agnew KJ, et al. Development of a nonhuman primate model for *Trichomonas vaginalis* infection. *Sex Transm Dis*. 2006;33:743–746.

105. Patton DL, Sweney YC, Bohannon NJ, et al. Effects of doxycycline and anti-inflammatory agents on experimentally induced chlamydial upper genital tract infection in female macaques. *J Infect Dis*. 1997;175:648–654.

106. Paul-Murphy J. Preventative medicine program for non-human primates. *Proc North Am Vet Conf*; 1992:736–738.

107. Pernikoff DS, Orkin J. Bacterial meningitis syndrome. an overall review of the disease complex and considerations of cross infectivity between great apes and man. *Proc Annu Conf Am Assoc Zoo Vet*; 1991:235–241.

108. Phillips IR, Grist SM. Clinical use of CT.1341 anaesthetic (“Saffan”) in marmosets. *Lab Anim*. 1975;9:57–60.

109. Popilskis SJ, Kohn DF. Anesthesia and analgesia in nonhuman primates. In: Kohn DF, Wixson SK, White WJ, et al. *Anesthesia and Analgesia in Laboratory Animals*. New York: Academic Press; 1997:233–255.

110. Popilskis S, Daniel S, Smiley R. *Effects of epidural versus intravenous morphine analgesia on postoperative catecholamine response in baboons*. Guelph, Canada: Proc 5th Internat Congr Vet Anesth; 1994.

111. Popilskis SJ, Lee DR, Elmore DB. Anesthesia and analgesia in nonhuman primates. In: Fish RE, Brown MJ, Danneman PJ, et al. *Anesthesia and Analgesia in Laboratory Animals*. 2nd ed. New York: Academic Press; 2008:336–363.

112. Puri SK, Singh N. Azithromycin. antimalarial profile against blood-and sporozoite-induced infections in mice and monkeys. *Exp Parasitol*. 2000;94:8–14.
113. Ramer JC, Emerson C, Paul-Murphy J. Analgesia in nonhuman primates. *Proc Annu Conf Am Assoc Zoo Vet*; 1998:480–483.
114. Ratterree MS, Didier PJ, Blanchard JL, et al. Vitamin C deficiency in captive nonhuman primates fed commercial primate diet. *Lab Anim Sci*. 1990;40:165–168.
115. Roberts JA. Primates. quarantine. Fowler ME, ed. *Zoo and Wild Animal Medicine. Current Therapy 3*. Philadelphia: WB Saunders Co; 1993:326–331.
116. Rolland RM, Chalifoux LV, Snook SS, et al. Five spontaneous deaths associated with *Clostridium difficile* in a colony of cotton-top tamarins. *Lab Anim Sci*. 1997;47:472–476.
117. Rosenberg DP. Nonhuman primate analgesia. *Lab Anim*. 1991;20:22–32.
118. Rossoff IS, ed. *Handbook of Veterinary Drugs and Chemicals*. Taylorville, IL: Pharatox Publishing Co, 1994.
119. Sainsbury AW, Eaton BD, Cooper JE. An investigation into the use of propofol in long-tailed macaques (*Macaca fascicularis*). *J Vet Anaesth*. 1991;18:38–41.
120. Salles CJ, Valls X, Marco A, et al. Anemia, myopathy, and/or steatitis in New World monkeys. *Proc Annu Conf Am Assoc Zoo Vet*; 1998:74–78.
121. Saslaw S, Carlisle HN. Studies on therapy of staphylococcal infections in monkeys. VIII. Comparison of cephalothin, cephaloridine, cefazolin, cephacetrile, and cephanone. *J Infect Dis*. 1973;128:S373–378. Suppl
122. Schaftenaar W. Evaluation of four years experience with medetomidine-ketamine anaesthesia in zoo animals. *Eur Conf Assoc Zoo Wildl Vet*; 1996:32–38.
123. Schobert E. Telazol® use in wild and exotic animals. *Vet Med*. 1987;82:1080–1088.

124. Shipley ST, Coksaygan T, Johnson DK, et al. Diagnosis and prevention of tuberculosis in a recently imported rhesus macaque (*Macaca mulatta*). *J Med Primatol*. 2008;37:20–24.
125. Sleeman JM, Cameron K, Mudakikwa AB, et al. Field anesthesia of free-living mountain gorillas (*Gorilla gorilla beringei*) from the Virunga volcano region. *J Zoo Wildl Med*. 2000;31:9–14.
126. Soma LR, Tierney WJ, Satoh N. Sevoflurane anesthesia in the monkey. the effects of multiples of MAC. *Hiroshima J Anesth*. 1998;24:3–14.
127. Southers JL, Ford EW. Preventive medicine. In: Bennet TB, Abee CR, Henrickson R. *Nonhuman Primates in Biomedical Research, Biology and Management*. San Diego: Academic Press; 1995:257–270.
128. Springer DA, Phillippi-Falkenstein K, Smith G. Retrospective analysis of wound characteristics and tetanus development in captive macaques. *J Zoo Wildl Med*. 2009;40:95–102.
129. Steffey EP, Baggot JD, Eisele JH, et al. Morphine-isoflurane interaction in dogs, swine and rhesus monkeys. *J Vet Pharmacol Therap*. 1994;17:202–210.
130. Steffey EP, Gillespie JR, Berry JD, et al. Cardiovascular effects of the addition of N<sub>2</sub>O to halothane in stump-tailed macaques during spontaneous and controlled ventilation. *J Am Vet Med Assoc*. 1974;165:834–837.
131. Sundelof JG, Hajdu R, Gill CJ, et al. Pharmacokinetics of L-749,345, a long-acting carbapenem antibiotic, in primates. *Antimicrob Agents Chemother*. 1997;41:1743–1748.
132. Sundelof JG, Thompson R, White KM, et al. Pharmacokinetics in nonhuman primates of a prototype carbapenem active against methicillin-resistant *Staphylococcus aureus*. *Antimicrob Agents Chemother*. 1996;40:795–798.
133. Swenson RB. Protozoal parasites of great apes. Fowler ME, ed. *Zoo and Wild Animal Medicine. Current Therapy 3*. Philadelphia: WB Saunders Co; 1993:352–355.

134. Tantaléan M, Gozalo A. Parasites of the Aotus monkey. Baer JF, Weller RE, Kakoma I. Aotus. The Owl Monkey. San Diego: Academic Press; 1994:353–374.
135. Thorton SM. Primates. In: Meredith A, Redrobe S. *BSAVA Manual of Exotic Pets*. 4th ed. Quedgeley, GB: British Small Animal Veterinary Association; 2002:127–137.
136. Tinker JH, Sharbrough FW, Michenfelder JD. Anterior shift of the dominant EEG rhythm during anesthesia in the Java monkey (*Macaca fascicularis*). correlation with anesthetic potency. *Anesthesiology*. 1977;46:252–259.
137. Valverde CR, Mama KR, Kollias-Baker C, et al. Pharmacokinetics and cardiopulmonary effects of fentanyl in isoflurane-anesthetized rhesus monkeys (*Macaca mulatta*). *Am J Vet Res*. 2000;61:931–934.
138. Wallace RS, Bell B, Prosen H, et al. Behavioral and medical therapy for self-mutilation and generalized anxiety in a bonobo. *Proc Annu Conf Am Assoc Zoo Vet*; 1998:393–395.
139. Walzer C. Diabetes in primates. Fowler ME, Miller RE. *Zoo and Wild Animal Medicine. Current Therapy 4*. Philadelphia: WB Saunders Co; 1999:397–400.
140. Watson JR, Stoskopf MK, Rozmiarek H, et al. Kinetic study of serum gentamicin concentrations in baboons after single-dose administration. *Am J Vet Res*. 1991;52:1285–1287.
141. Weld KP, Mench JA, Woodward RA, et al. Effect of tryptophan treatment on self-biting and central nervous system serotonin metabolism in rhesus monkeys (*Macaca mulatta*). *Neuropsychopharmacology*. 1998;19:314–321.
142. Whelan G, James MF, Samson NA, et al. Anaesthesia of the common marmoset (*Callithrix jacchus*) using continuous intravenous infusion of alphaxalone/alphadalone. *Lab Anim*. 1999;33:24–29.
143. White GL, Cummings JF. A comparison of ketamine and ketamine-xylazine in the baboon. *Vet Med Small Anim Clin*. 1979;74:392–396.
144. Williams CV, Glenn KM, Levine JF, et al. Comparison of the efficacy and

cardiorespiratory effects of medetomidine-based anesthetic protocols in ring-tailed lemurs (*Lemur catta*). *J Zoo Wildl Med*. 2003;34:163–170.

145. Wissman M, Parsons B. Surgical removal of a lipoma-like mass in a lemur (*Lemur fulvus fulvus*). *J Small Exotic Anim Med*. 1992;2:8–12.

146. Wolf RH, Gibson SV, Watson EA, et al. Multidrug chemotherapy of tuberculosis in rhesus monkeys. *Lab Anim Sci*. 1988;38:25–33.

147. Wolff PL. Parasites of the new world primates. Fowler ME, ed. *Zoo and Wild Animal Medicine. Current Therapy 3*. Philadelphia: WB Saunders Co; 1993:378–389.

148. Yamano K, Kanetoshi A, Goto A, et al. Japanese monkey (*Macaca fuscata*) with alveolar echinococcosis after treatment with albendazole for 10 years. serodiagnosis and determination of albendazole metabolites. *Parasitol Res*. 2009;106:69–74.

149. Young LA, Lung NP, Isaza R, et al. Anemia in a chimpanzee (*Pan troglodytes*) associated with lead toxicity and uterine leiomyoma. *Proc Annu Conf Am Assoc Zoo Vet*; 1994:287.

150. Young LA, Morris PJ, Keener L, et al. Subcutaneous *Taenia crassipes* cysticercosis in a red ruffed lemur (*Varecia variegata rubra*). *Proc Annu Conf Am Assoc Zoo Vet*; 2000:251–252.

## Wildlife

David L. McRuer, Natalie H. Hall

TABLE 13-1 Checklist for the Care of Sick, Injured, or Orphaned Wildlife.<sup>a</sup>

The information contained within this section is designed to help a veterinarian triage and provide basic stabilizing care to injured or orphaned wildlife. The veterinarian is strongly encouraged to transfer these animals to or consult with experienced wildlife veterinarians or wildlife rehabilitators as soon as possible. In addition, any individual working with wildlife should check with state and federal officials on permit requirements. In the event of any bites inflicted by rabies vector species or wild mammals showing neurologic signs to persons or domestic pets, the local health department should be contacted regarding appropriate rabies prevention procedures.

### A. Regulations and reporting

a. Permits: check with state and federal officials on laws and permit requirements for hospitalizing wildlife; if you do not have permits, stabilize the animal and transport it to a permitted facility as soon as possible.

b. Species reporting: check with state wildlife officials for a list of reportable endangered, threatened, or listed species; these may vary from state to state.

c. Illegal activity: report injuries caused by illegal activities such as gunshot wounds to non-game species to local, state, or federal wildlife authorities.

d. Reportable diseases: reportable or foreign animal diseases diagnosed in wildlife should be reported to the USDA-APHIS Area Veterinarian-in-charge ([http://www.aphis.usda.gov/animal\\_health/area\\_offices/](http://www.aphis.usda.gov/animal_health/area_offices/)).

e. Banded birds: band numbers on federally banded birds should be reported to the US Geological Survey Bird Banding Laboratory (<http://www.pwrc.usgs.gov/bbl/>).

f. Advise the public not to approach rabies vector species and to contact local authorities instead. In addition, bats should never be handled bare handed. If a rescuer has handled a rabies vector species, report any potential rabies exposure (bite or contact with saliva through broken skin or mucous membranes) to the local health department.

### B. Patient background

a. Is the “orphan” truly an orphan? If not, return to nest or site found since natural parents provide

the best care. Human scent will not cause rejection of the young by the mother.

- i. Fledgling birds normally spend time on the ground before gaining full flight ability. The parents will continue to feed and guard the fledgling.
- ii. Adult rabbits and deer normally leave their young unattended for much of the day. Parents will return to the site where offspring were left to reunite, often hours later. Check for a “milk line” in young rabbits to determine if they were recently fed.

b. Get precise information. When was animal found? Exact location? Circumstances? Has any medical or supportive care been provided?

c. Obtain rescuer’s name, address, and phone number in case further details are required.

C. Initial patient triage

a. What is medically wrong with the animal? Can it be treated, survive the rehabilitation period (sometimes months), and be released or placed into an education program? Unfortunately, euthanasia is often required.

b. Address life-threatening problems first. ABC: Check that the *airway* is clear, the animal is *breathing*, and *cardiac beat and pulse* are present. Provide cardiopulmonary resuscitation if needed.

c. Control hemorrhage. Total blood loss of more than 1% of body weight is considered an emergency. Remove broken blood feathers by pulling feather shaft out of follicle with straight, steady pressure. Apply direct pressure to hemorrhage sites. Use topical epinephrine, cautery, and ligation if needed.

d. Assess for shock. Evaluate neonates for hypoglycemia and hypothermia. Clinical signs include cold extremities, pale and tacky mucous membranes, and rapid heart rate. Treat with fluids, supplemental heat if needed, and treat hypoglycemia with intravenous or oral dextrose. Treat hyperthermia with fluids, placing patient in a cool place, and spraying limbs with cool water.

e. Perform full examination once patient is stable. Examination may need to be delayed, limited to a cursory exam, or done in stages to minimize patient stress.

- i. If possible, determine species, gender, life stage, body condition, weight.
- ii. Is zoonotic disease or infectious disease a concern? Isolate patient if necessary.

D. Develop treatment and supportive care plan

a. Assume most wildlife patients are 10% dehydrated on admission. Provide hydrating solutions and electrolyte support for the first 24 to 48 hours parenterally (Normasol, 2.5% dextrose, LRS, 0.9% saline) or orally with Pedialyte (Abbott), Gatorade (Gatorade), or Bounce Back (Manna Pro). Continue to treat if ongoing fluid losses occur. Most birds, reptiles, and mammals can be triaged with fluids based on an assumed maintenance rate of 40-60 mL/kg/day, 10-25 mL/kg/day, and 60



- mL/kg/day, respectively.
- b. Provide supplemental heat to neonates at 80-90°F (27-32°C). Keep heating pads on low to prevent thermal burns. Use wrapped hot water bottles and warmed air.
  - c. Treat and prevent infection. Most open wounds will require antimicrobial therapy.
  - d. Provide analgesia and antiinflammatory medications if needed. Nonsteroidal antiinflammatory drugs are useful for soft tissue injury, head trauma, and spinal trauma. Steroids may be useful for acute spinal trauma and shock in mammals however their use in birds may be controversial. Opioids are useful for severe soft tissue injury and fractures.
  - e. Develop nutritional plan (see additional appendices for diets and husbandry guidelines). Attempt to calculate the calories needed for each day's feeding. Except for neonates, do not provide food for the first 24 hours while the animal is being rehydrated. Emaciated animals may need special diets (Emeraid Nutritional Care System [Lafeber]) to avoid refeeding syndrome.
  - f. Neonatal animals must be stimulated to urinate and defecate by gently brushing anal and genital areas with moist cotton or clean tissue after each feeding.
  - g. Determine appropriate housing. The main goals are safety and to reduce stress on the animal by preventing noise and visual stimulation. In general, minimize contact to people and domestic animals.

E. Rehabilitation

- a. Contact the International Wildlife Rehabilitation Council (707-864-1761; [www.iwrc-online.org](http://www.iwrc-online.org)) or the National Wildlife Rehabilitators Association (320-259-4086; [www.nwrawildlife.org](http://www.nwrawildlife.org)) to find a rehabilitator near you.
- b. Transfer the animal to a qualified rehabilitator for continued therapy and to prepare the animal for release.
- c. Rehabilitators are often familiar with animal nutrition and natural history and can provide initial supportive care recommendations as well.

F. Release criteria

- a. Animals must meet the following criteria in order to be released to the wild:
  - i. Initial illness or injury is resolved with no risk of recurrence.
  - ii. All secondary problems have been resolved.
  - iii. The animal does not pose an unnatural risk to the wild population, humans, or the environment.It is not likely to spread pathogens or contribute to disease processes in other ways. The animal does

not pose a zoonotic risk.

iv. The animal can effectively avoid predators.

v. The animal is able to find food by foraging or hunting in the wild.

vi. The animal can function reasonably within the population and can reproduce.

b. Animals should be released at the original site of capture unless conservation efforts or safety considerations dictate otherwise. Animals should be released in their natural environment and habitat suitable for species survival but in areas away from traffic, people, and pets. The habitat must be within carrying capacity for the species. Release diurnal species in the morning and nocturnal species at dusk. Check local and state laws regarding release of rabies vector species and deer.

c. Animals that cannot be returned to the wild for any reason should be euthanized unless they can be placed in educational, breeding, or research programs.

### *Web resources:*

National Wildlife Rehabilitation Association

—<http://www.nwrawildlife.org/home.asp>

International Wildlife Rehabilitation Council—<http://theiwrc.org/>

Wildlife Center of Virginia—[www.wildlifecenter.org](http://www.wildlifecenter.org)

Wildlife Disease Information Node—<http://wildlifedisease.nbii.gov/>

USGS National Wildlife Health Center—<http://www.nwhc.usgs.gov/>

U.S. Fish and Wildlife Service—<http://www.fws.gov/>

Southeastern Cooperative Wildlife Disease Study—<http://www.scwds.org/>

Birds of North America Online—<http://bna.birds.cornell.edu/bna/>

World Organization for Animal Health—[http://www.oie.int/eng/en\\_index.htm](http://www.oie.int/eng/en_index.htm)

National Association of State Public Health

Veterinarians—<http://www.nasphv.org/>

<sup>a</sup> See references in following appendices.

TABLE 13-2 Recommendations for the Captive Management of Carnivores/Omnivores. [2-4,6-8,10-12,17-19,21,23,25,26,29,31,32,36,38,44](#)

| Topic                     | Notes <sup>a,b</sup>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
|---------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Feeding Guidelines</b> |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
|                           | All young carnivores need the anogenital region stimulated after each feeding for urination/defecation. Very difficult to rear and release single animals.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
| Badger                    | Esbilac (PetAg) or Zoologic Milk Matrix 42/25 (76%) + 30/55 (24%) (PetAg); 2-3× daily; wean at 8-10 wk onto canned and dry dog or cat food and native food.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
| Bobcat/Canada lynx        | KMR (PetAg), Esbilac (PetAg), or Zoologic Milk Matrix 42/25 (PetAg) and yogurt; 6-8× daily; provide 250 mg taurine per day if milk replacer is not already supplemented. Feed with orphan kitten bottle until drinking formula from a pan. Feed 15-20% of body weight/day split between feedings. Wean starting at 5 wk onto kitten chow or Mazuri Feline Diet soaked in formula and rodents. Gradually introduce live rodents.                                                                                                                                                                                                                                                                                                                                                                                                                                            |
| Coyote                    | Esbilac (PetAg), Zoologic Milk Matrix 30/55 (51%) + 42/25 (37%) + 33/40 (12%) (PetAg), or Fox Valley 34/40; 2-4× daily; wean at 5-7 wk onto puppy canned or dry food and rodents (e.g., chopped skinned rats or pureed mice) with 5% fruit and 5% vegetables. May begin nibbling on pureed rodents (or dog food) at 10 days of age. Gradually introduce live rodents.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| Gray and red fox          | Esbilac (PetAg), Zoologic Milk Matrix 33/40 (56%) + 20/14 (26%) + 42/25 (18%) (PetAg), or Fox Valley 35/32 using an orphan kitten bottle. Once eyes are open, start offering formula in a dish. Feed neonates 5% of body weight at each feeding; 100-200 g kits 7-8× daily; 200-400 g kits 6× daily; 400-900 g kits 5× daily; 900-1000 g kits 4× daily. May begin nibbling on pureed rodents (or soaked puppy chow) at 10 days of age. Start weaning at 3 wk by offering puppy chow soaked in formula in a shallow dish. At 6 wk, reduce formula and gradually start adding canine diet, thawed rats/mice, fruits. Wean at 7-8 wk onto puppy canned and dry food, rodents (e.g., pureed mice) with 5% fruit and 5% vegetables. Gradually introduce live rodents. Feed adults canine food with thawed rats/mice and 10% vegetables.                                         |
| Raccoon                   | KMR (PetAg), Zoologic Milk Matrix 42/25 (100%) (PetAg), Zoologic Milk Matrix 42/25 (87%) + 20/14 (13%), or Fox Valley 40/25. Wear latex gloves due to risk for <i>Baylisascaris procyonis</i> . If eyes still closed or weak, can tube feed by nasoesophageal gavage with a 8-, 10-, or 12-Fr red rubber catheter; otherwise dish feed. Until 3-4 wk of age, feed 5% body weight 6× daily until 500 g then reduce to 4× daily. At 400 g start offering raccoon mush (soaked puppy chow, Gerber high-protein baby cereal, KMR powder, add water to make an oatmeal-like consistency). Reduce feedings to 3× daily at 800 g, 2× daily at 1000 g, once daily at 1100 g, and fully wean at 1200 g. At 1200 g, start to add hard puppy chow to mush diet and after 2 kg, give adult diet of hard puppy chow, whole prey items such as mice/fish, and 10% fruits and vegetables. |
| Skunk                     | Esbilac (PetAg), Zoologic Milk Matrix 30/55 (78%) (PetAg) + Non-fat Dry Milk (22%) or Fox Valley 32:45; 2-4× daily depending on the age; wear latex gloves due to risk for <i>Baylisascaris columnaris</i> . Wean at 6-8 wk onto dry puppy food, rodent                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |

|                       |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
|-----------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                       | pellets, and native food. Add 10% vegetables and 5% fruit. Feed adults dog food, thawed rodents, eggs, insects, worms, fruits, and berries.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
| River otter           | Zoologic Milk Matrix 30/55 (100%) (PetAg); Fox Valley 30/50; 3 parts Esbilac (PetAg) + 1 part heavy cream + 4 parts water; otters <4 wk, feed 2 Tbs per 4 oz of body weight divided between 5-7 feedings. Feed every 2-3 hr during daylight hr with the last feeding at 10 pm. At 4 wk, feed 1 oz 3-6× daily. At 6 wk, feed 2.5 oz 4× daily. At 8 wk, add a small amount of rice cereal to the formula and introduce small bits of adult food. At 10 wk, add ground fish, tadpoles, or growth kitten food to diet. Offer free choice smelt and dry kitten food between feedings. Offer water for drinking. At 7 mo, otters may weigh ~14 lb (6.4 kg) and may be given 4 oz canned feline Hill's Science Diet + ¾ lb caplin + ¾ lb smelt + 4 baby carrots all divided into 3 feedings during a 24-hr period. Adult diet mainly consists of fish (cut if large) with occasional alternatives such as chicken necks, boiled eggs, crickets, giant mealworms, mice, etc. |
| <b>Critical Care</b>  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
|                       | Tube feed critical adults a carnivore diet such as Lafeber Emeraid carnivore formula, Oxbow carnivore care, or Hill's a/d canine/feline critical care diet.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
| <b>Housing</b>        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
|                       | Animals that are imprinted or habituated should not be released. To avoid imprinting, limit human contact and avoid talking within hearing distance of animal. Offer food by self-feeder or with visual blinds when possible.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
|                       | House newborns in neonatal incubator or small kennel kept at 85°F (29.4°C) with 60-70% humidity. Juvenile kits/cubs may be kept in a towel-lined cardboard box inside a kennel with a heating pad under one half for warmth. Ignore crying by kits and cubs. Do not offer water in enclosures until the animals have their eyes open. At weaning, animals can be moved to enclosed outdoor pens and supplemental heat gradually decreased. Once weaned, animals can be kept in full outdoor enclosures with hiding spots (logs/airline kennels). If housing an adult in an airline kennel, keep a towel over the door to reduce visual stimulus and stress.                                                                                                                                                                                                                                                                                                          |
|                       | Raccoons have articulate forepaws that make them capable of opening doors and latches. Provide towels and litter box in cage and if possible a small hammock. Sturdy food and water bowls should be used. <i>Baylisascaris procyonis</i> ova are virtually indestructible and may last in the environment for years. House in a kennel that can be discarded or properly disinfected by flame torch.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
|                       | River otters should not be introduced to water until 3 mo of age. Otter pups can easily drown so start with a small bowl. When they can blow bubbles, increase pool size but ensure the pup can still stand. Increase tank size with ability. Always towel off pups after swimming. Include safe toys as otters are very curious.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
| <b>Safe Restraint</b> |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
|                       | Always wear latex gloves under leather work gloves during restraint of an animal. Wear eye protection when handling species that spray, such as skunks.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
|                       | Badgers, foxes, coyotes, bobcats, and lynx—young kits/cubs weighing less than 1 kg can be handled by wearing latex gloves under long leather gloves and caught up by wrapping in a thick towel or blanket. For long procedures or fractious adults,                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |

anesthetize by injectable/inhalant combinations. Larger animals over 3 kg inject using squeeze cage, netting, or syringe pole. Do not scruff animals for restraint since they can still turn and bite. Restrain by grasping the head around the back of the neck and holding the dorsal pelvis with the legs aimed away from your abdomen to avoid personal injury. Use muzzles to prevent biting.

Raccoons—infants/juveniles may be restrained by the scruff of the neck or by holding the shoulder area of the forelegs with one leg in each hand. Animals tend to scream, grasp, or bite at the gloves and may urinate with handling. Restrain older juveniles and adults with chemical or a combination of chemical and gas anesthesia.

Skunk—limit handling in this species to avoid being sprayed from the musk glands. For young animals, attempt to drape a towel or plastic sheet and tuck the tail between the hind legs to decrease the possibility of being sprayed. Restrain older juveniles and adults with chemical and/or gas anesthesia.

River otters—natural defense is to bite, grasp, and twist which may cause significant tissue trauma. Adult animals may need to be anesthetized for restraint.

### Physical Examination Notes

Badger age determination—newborn weighs 90-100 g; first teeth erupt at 4 wk; eyes open at 5 wk; weaning starts at 2-3 mo; fully weaned by 5-6 mo. Adult weights: 6-8 kg in summer and 8-12 kg in fall.

Bobcat/Canada lynx age determination—eyes open 11-14 days after birth. Bobcat deciduous teeth erupt in the following sequence: incisors 11-14 days, canines 11-14 days, premolars 4-7 wk. Permanent teeth erupt: incisors 17-21 wk, canines 22 wk, premolars 24-29 wk, molars 23-28 wk. Bobcat weights: neonates up to 283-368 g; adults range 4-15 kg. Lynx weights: neonates range 197-211 g; adults range 5.1-17.2 kg.

Coyote age determination—newborn 250-300 g; eyes open 13-14 days; incisors and canines erupt at 2-3 wk. Adults weigh 9-16 kg.

Fox age determination—newborn weighs 100 g, blind, deaf, 10 cm long, short black fur; eyes open at 11-14 days; by 4 wk kits are walking and fur is beginning to shed. Deciduous teeth erupt in the following sequence: incisors 18-22 days, canines 21-22 days, premolars 22-29 days. Permanent teeth erupt: incisors 15-18 wk, canines 17-19 wk, premolars 15-22 wk, molars 16-27 wk. At 5-6 wk, kits weigh 600-700 g; by 8-20 wk, kits are completely weaned, snout and ears become long and pointed, and are learning to hunt with parents; by 6 mo, kits weigh at least 3.5 kg and are ready for independence from parents but usually stay with parents for a year. Adults weigh 3-10 kg (gray foxes generally smaller than red foxes).

Raccoon age determination—newborn 60-75 g, back sparsely furred and eyes and ears are closed. At 2 wk, face mask is fully haired as well as the back. At 1.5-3 wk, ears and eyes are open. At 3 wk, the tail rings are fully furred. At 3-4 wk, the kits squirm actively and chitter but cannot support their weight on their legs. At 4 wk, deciduous incisors erupt. At 4-6 wk, the animals begin walking. At 6 wk, deciduous 2<sup>nd</sup>-4<sup>th</sup> premolars erupt. At 8 wk, deciduous first premolars and permanent first incisors erupt. At 10 wk, permanent second incisors and first molars erupt. At 12 wk, permanent third incisors erupt. At 14 wk, permanent canines erupt. By 16 wk, most

|                             |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
|-----------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                             | wild animals are weaned. Adults weigh up to 12 kg.                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
|                             | Skunk age determination—eyes open 22-35 days; ears open 24-27 days; musk glands fully developed at 28 days; wean at 2 mo. Adults weigh 1.2-2.5 kg up to 5.3 kg in fall.                                                                                                                                                                                                                                                                                                                                                |
|                             | River otter age determination—eyes open between 31-33 days but cannot focus until 50-60 days. Day 36, pup will walk with unsteady movements. Day 60, pup will put head under water. Day 57-60, pup will begin to eat solid food. Birth weight is 128 g. Weight guidelines are as follows: week 1, 266 g; week 2, 515 g; week 3, 660-900 g; week 4, 757-1180 g; week 5, 997-1560 g; week 6, 1200-1428 g; week 7, 1160-2072 g; week 8, 1650-1907 g; week 9, 1914-2300 g; week 10, 1670-2420 g. Adults weigh up to 15 kg. |
| <b>Venipuncture</b>         |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
|                             | Medial saphenous vein, lateral saphenous vein, jugular vein, cephalic vein, ventral coccygeal vein, femoral vein, cranial vena cava (in otters).                                                                                                                                                                                                                                                                                                                                                                       |
| <b>Fluid Administration</b> |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
|                             | Subcutaneous between shoulder blades; intravenous in medial and lateral saphenous vein, cephalic vein, jugular vein; intraosseus in small critically ill animals.                                                                                                                                                                                                                                                                                                                                                      |
|                             | Maintenance fluid rate 60 mL/kg/day                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
|                             | Hetastarch dose 10-15 mL/kg/day                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
| <b>Release Tips</b>         |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
|                             | Release of young animals: badgers ~5 mo; black bear ~45 kg; bobcats/lynx ~4-5 mo; coyote ~5-6 mo; foxes ~5-6 mo; raccoons ~3.5 kg; skunks ~3-4 mo; river otters ~7-12 mo.                                                                                                                                                                                                                                                                                                                                              |

<sup>a</sup> Although this outline is intended to provide general guidelines for the care of injured wildlife, the veterinarian is strongly encouraged to transfer these animals to experienced rehabilitators as soon as possible and/or to contact rehabilitators if questions arise. In addition, any individual working with wildlife should check with state and federal officials on permit requirements.

<sup>b</sup> Avoid overfeeding of orphaned wild mammals.

TABLE 13-3 Recommendations for the Captive Management of Opossums. [9-10,12,14,17,20-21,27,31,33,36,43](#)

| Topic                     | Notes <sup>a</sup>                                                                                                 |
|---------------------------|--------------------------------------------------------------------------------------------------------------------|
| <b>Feeding Guidelines</b> |                                                                                                                    |
|                           | Stimulate neonates to urinate and defecate at feedings by gently wiping anogenital area with soft gauze or tissue. |
|                           | Neonates: 20-35 g tube feed with 3.5-Fr red rubber feeding tube. Use 5-Fr tube for 36-60 g                         |

|          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |
|----------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Nestling | patients or syringe feed using IV catheter without stylet for all neonates. For neonates weighing 10-20 g, feed 0.5 mL 5×/day; 21-30 g, feed 0.5-1 mL 5×/day; 31-54 g, feed 1.5-2 mL 3×/day; 55-74 g, feed 2.5-3.5 mL 2×/day; 75-100 g, feed 4-5 mL 1×/day. Formulas: before eyes open, feed 2 parts Esbilac powder (PetAg), 1 part Zoologic Milk Matrix 30/55 powder (PetAg), 4 parts warm water, ½ tsp dicalcium phosphate (26:18.5) powder (UPCO). After eyes open, feed 1 part Esbilac powder, 2 parts warm water, ½ tsp dicalcium phosphorus powder. Feeding over 8% body weight can result in diarrhea. |
| Weanling | Start weaning at 45 g with juvenile mash in a bowl. Mash is 2 Tbs infant opossum tube feeding formula, 1 Tbs baby rice cereal, and 2 Tbs high-quality puppy kibble. Check stomach for fullness and reduce tube feedings to avoid overfilling. At 55-75 g, offer small pieces of soft food and free choice water. At 75-100 g, offer finely chopped mice. Fully wean by 100 g. Calcium supplementation is recommended.                                                                                                                                                                                         |
| Juvenile | 100-200 g individuals. Juvenile meal is 4 Tbs soaked puppy chow, 1 Tbs meat-based baby food, 2 Tbs canned puppy food, 1 Tbs cat chow, several small chunks of soft vegetables (i.e., broccoli, carrots, cauliflower, sweet potato, squash), 1-2 pieces of finely chopped fruit, and ⅓ of a chopped mouse with bones included.                                                                                                                                                                                                                                                                                 |
| Adult    | Feed 6 Tbs of dry cat food, ½ cup small vegetable chunks, 2-3 small pieces of fruit, 7 Tbs canned dog food, several earthworms, 1 hard-boiled egg with shell, and one whole mouse. Calcium supplementation is recommended.                                                                                                                                                                                                                                                                                                                                                                                    |

### Critical Care

|  |                                                                                                                                                         |
|--|---------------------------------------------------------------------------------------------------------------------------------------------------------|
|  | Syringe or tube feed high protein diet such as Emeraid Lafeber carnivore formula, Oxbow carnivore care, or Hill's a/d canine/feline critical care diet. |
|--|---------------------------------------------------------------------------------------------------------------------------------------------------------|

### Housing

|  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
|--|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|  | Incubate but not over 95°F (35°C) in sturdy box or aquarium. Use towels and a small box to provide a nest/pouch. Once walking, house in a cage with mesh too small for the head to pass through. Line the floor with newspaper to prevent foot trauma. Avoid towels with terry-cloth or loops in which nails can become caught. Group animals of similar size together shortly before eyes open (before 45 g). To prevent cannibalism, avoid overcrowding and isolate wounded animals. House adults in sturdy enclosures with a hiding spot. |
|--|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|

### Safe Restraint

|  |                                                                                                                                                                |
|--|----------------------------------------------------------------------------------------------------------------------------------------------------------------|
|  | Appropriate protective gear includes elbow length leather gloves for protection against teeth and nails. Anesthesia may be required for examination of adults. |
|--|----------------------------------------------------------------------------------------------------------------------------------------------------------------|

### Physical Examination Notes

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|--|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|  | Joeys stay attached to teat for 60 days; eyes open about 63 days; weaning at 87 to 104 days. Euthanasia is recommended for opossums less than 20 g due to difficulties associated with tube feeding. Remove from teat carefully taking care not to injure jaw. Joeys nursing on deceased Jill should receive prophylactic antibiotics.                                |
|  | Epipubic bones are palpable in caudal abdomen. Have a cloaca instead of separate anogenital orifices. Body temperature ranges from 91.4°F-96.8°F (33-36°C). <i>Besnoitia darlingi</i> parasitism causes generalized, diffuse, small palpable nodules in subcutaneous tissue that are visible on radiographs. Lifespan is ~1-2 years in wild, ~2-3 years in captivity. |



|                             |                                                                                                       |
|-----------------------------|-------------------------------------------------------------------------------------------------------|
| <b>Venipuncture</b>         | Lateral coccygeal and ventral tail vein/artery, cephalic vein, saphenous vein, pouch vein in females. |
| <b>Fluid Administration</b> |                                                                                                       |
|                             | Sites: SC supra/intrascapular area, flank; 100-200 mL per site.                                       |
|                             | Maintenance rate 60 mL/kg/day.                                                                        |
| <b>Release Tips</b>         |                                                                                                       |
|                             | Release if self-feeding, acclimated to the outdoors, and at least 4-5 months old (≥500 g).            |
|                             |                                                                                                       |
|                             | Amoxicillin 10 mg/kg PO q12h                                                                          |
|                             | Ceftiofur 2 mg/kg IM q24h × 7-10 days                                                                 |
|                             | Buprenorphine 0.01 mg/kg SC, IM q6-8h                                                                 |
|                             | Carprofen 1 mg/kg PO, SC q12-24h                                                                      |
|                             | Meloxicam 0.2 mg/kg PO, SC q24h                                                                       |
|                             | Diazepam 0.5-2 mg/kg PO, IM, IV, once                                                                 |
|                             | Itraconazole 5 mg/kg PO q24h × 5 days for gastrointestinal candidiasis                                |
|                             | Nystatin 50,000 U PO q8h for joeys with gastrointestinal candidiasis                                  |

<sup>a</sup> Although this outline is intended to provide general guidelines for the care of orphaned wildlife, the veterinarian is strongly encouraged to transfer these animals to experienced rehabilitators as soon as possible and/or to contact rehabilitators if questions arise. In addition, any individual working with wildlife should check with state and federal officials on permit requirements.

TABLE 13-4 Recommendations for the Captive Management of Cottontail Rabbits. [4,12,21,24,29,31,33-37](#)

| Topic                     | Notes <sup>a-c</sup>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
|---------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Feeding Guidelines</b> |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |
|                           | Stimulate neonates to urinate and defecate at feedings by gently wiping anogenital area with soft gauze or tissue.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
| Nestling                  | Esbilac (PetAg) and Multi Milk (PetAg) 3:2 (1.91 kcal/mL); Esbilac powder, Multi Milk powder, and water 1:1:1.5 (2.01 kcal/mL); KMR (PetAg), Multi Milk powder 2:1 (1.73 kcal/mL); Esbilac powder, heavy cream, water 1:0.25:1 (1.93 kcal/mL). Prior to feeding, correct hypothermia and dehydration with SC or PO electrolytes (Pedialyte, Abbott); first feeding give 1:1 formula and electrolyte; if feeding is well tolerated give 100% formula on the next feeding. If rabbit is BAR, syringe feed with 1 or 3 cc syringe in the corner of the rabbit’s mouth. If too weak, tube feed with red rubber tube. Feed 2-3×/day. Give 100-125 mL/kg at each feeding. After feedings clean face and stimulate anogenital region to induce urination/defecation. |



|                                    |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
|------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Weanling                           | Cottontails wean at 150-200 g body weight. Offer roughage once eyes are open. Once eating roughage, reduce formula feeding to once daily. Wean completely after another 5-7 days. If available, feed cecotrophs from adults to pre-weanling rabbits for 2-3×/wk until fully weaned.                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| Juvenile/adult                     | Offer roughage including leafy greens, good quality grass hay such as timothy/orchard/oat (not alfalfa), lettuces (not iceberg), kale, broccoli, parsley, cilantro, dandelion greens, collards, mustard greens, turnip greens. Avoid apples and carrots (high in sugars) and processed cereals.                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
| <b>Critical Care</b>               |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
|                                    | If not eating, syringe feed juvenile/adults Oxbow Herbivore Critical Care or Lafeber Emeraid Herbivore Nutritional Care.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
| <b>Housing</b>                     |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
|                                    | Incubate neonates at 80-85°F (26.7-29.4°C); house weanlings at 70-75°F (21-23.9°C); once weaned keep outdoors in wire mesh bottom cage with areas of solid flooring to prevent foot lesions. Provide hide areas and natural cover to prevent stress.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| <b>Safe Handling and Restraint</b> |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
|                                    | Appropriate protective gear includes a towel or light gloves for adults. Cover with a towel before picking up to reduce stress. Restrain so that patient cannot kick out and injure its back. Avoid over handling and anesthetize for prolonged restraint.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |
| <b>Physical Examination Notes</b>  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
|                                    | Body temperature should be 100-103°F (37.5-39.5°C); obligate nasal breathers; cannot vomit. Cecotrophs (large soft brown-green feces) are normal and are usually passed and consumed overnight. Check newly acquired neonates for a “milk line” (hold the rabbit in a vertical position and look for a white line in the stomach seen through the skin) which indicates the neonate was recently fed and should be returned to the nest. Neonates (still in the nest) are born with only fine slate grey fur on their back, eyes shut, the ears lie flat against the back, and their bodies are 5 cm (2 in) long. Young rabbits that are 10 cm (4 in) in length, whose ears are erect, and can hop quickly are at least 3 weeks old and are independent. |
| <b>Venipuncture Sites</b>          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
|                                    | Jugular vein, cephalic vein, femoral vein, lateral saphenous vein.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
| <b>Fluid Administration</b>        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
|                                    | Sites: IV catheter in cephalic or lateral saphenous vein (visualize above the hock); SC between the scapulae.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
|                                    | Maintenance rate is based on daily water consumption (100-150 mL/kg/day) and should be given in 2-3 equal treatments over a 24-hr period.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
| <b>Natural History</b>             |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
|                                    | Doe normally leaves young unattended for long periods between feedings and will avoid nest in the presence of predators such as dogs, cats, and humans. Verify nestlings are truly orphaned prior to permanent removal from nest.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
| <b>Release Tips</b>                |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
|                                    | Release at 5 wk of age once weaned and acclimated to local outdoor temperatures.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |

Release early in the day in an area with plenty of brush for hiding.

### Commonly Used Medication

Improper antibiotic therapy causes gastric dysbiosis so avoid narrow spectrum antimicrobials such as amoxicillin, penicillin, ampicillin, clindamycin, lincomycin, erythromycin, and cephalosporins. See rabbit chapter ([Chapter 9](#)) for pharmacology information.

<sup>a</sup> Although this outline is intended to provide general guidelines for the care of injured wildlife, the veterinarian is strongly encouraged to transfer these animals to experienced rehabilitators as soon as possible and/or to contact rehabilitators if questions arise. In addition, any individual working with wildlife should check with state and federal officials on permit requirements.

<sup>b</sup> Avoid overfeeding of orphaned wild mammals.

<sup>c</sup> In order to prevent aggressive behavior between individuals, avoid housing weaned rabbits together in the same enclosure if they were not introduced prior to weaning.

TABLE 13-5 Recommendations for the Captive Management of Wild Rodents. [4,6,10,11,21,28,33,36](#)

| Topic                     | Notes <sup>a</sup>                                                                                                                                                                                                                                                                                                                                                                                          |
|---------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Feeding Guidelines</b> |                                                                                                                                                                                                                                                                                                                                                                                                             |
|                           | Stimulate neonates to urinate and defecate at feedings by gently wiping anogenital area with soft gauze or tissue.                                                                                                                                                                                                                                                                                          |
| Neonate                   | Neonates typically need 0.4-0.8 kcal/g of body weight per day.                                                                                                                                                                                                                                                                                                                                              |
|                           | Beavers: Esbilac (PetAg) and Multi Milk (PetAg) 2:1 or Esbilac and Zoologic 30/55 (PetAg) and water 2:2:3; feed 3-4× daily.                                                                                                                                                                                                                                                                                 |
|                           | Squirrels: Esbilac, Multi Milk, Zoologic 30/55 mixed 1:1 with water; Fox Valley 32/40 mixed 3:1 with water; administer formula in syringe with animal on its belly allowing squirrel to grasp syringe with front feet; feed 6-8× daily.                                                                                                                                                                     |
|                           | Woodchucks and marmots: Esbilac or Zoologic 33/40 and water 4:5; feed 2-4× daily.                                                                                                                                                                                                                                                                                                                           |
|                           | Rehydrate neonates prior to starting formula with oral electrolytes; initiate formula administration by feeding formula:electrolytes at 1:3, then 1:1, then 3:1 mixtures. If at any time patient becomes bloated or has diarrhea/vomiting, return to the previously tolerated dilution. Initially, feed no more than 5% body weight per feeding. This may be increased up to 7% once patient is over 100 g. |
| Weanling                  | Beavers: wean at 8 wk onto rodent pellets and native food (shrubs, twigs, branches, dark leafy greens, etc.).                                                                                                                                                                                                                                                                                               |

|       |                                                                                                                                                                |
|-------|----------------------------------------------------------------------------------------------------------------------------------------------------------------|
|       | Squirrels: wean by 6 wk onto rodent pellets, vegetables, fruit, and a variety of nuts and grains.                                                              |
|       | Woodchucks and marmots: wean at 6-8 wk onto rodent or rabbit pellets and native forage (vegetables, fresh grasses, dandelions, grains, fruit, seed, and nuts). |
| Adult | Rodent pellets, vegetables, grains, fruits, nuts; provide native forage for beavers (include branches), woodchucks, and marmots.                               |

## Critical Care

|  |                                                                                                                                                                                                                                |
|--|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|  | If not eating, syringe feed juvenile/adults Oxbow Herbivore Critical Care or Lafeber Emerald Herbivore Nutritional Care to strictly herbivorous species. Omnivorous species may receive both herbivore and carnivore formulas. |
|--|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|

## Housing<sup>b</sup>

|  |                                                                                                                                                                                                                                                                                                                                                                                                                       |
|--|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|  | Neonates should be housed in incubator at 85-90°F (30-32°C) and humidity at 70-80%. Juveniles need to be housed in a chew-proof and escape-proof wire cage or aquarium with a hide-box containing towels. Line cage with paper or towels. Minimize human exposure to prevent habituation/imprinting. Adults should be housed in a chew-proof wire cage/crate/enclosure with a hiding place and branches for climbing. |
|--|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|

## Safe Handling and Restraint

|  |                                                                                                                                                                                                                                                         |
|--|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|  | Adults of these species can deliver hard bites. Appropriate protective wear includes leather gloves to the elbow. Use nets for initial restraint of larger rodents. A noose-style catch pole may be appropriate for initial restraint of large beavers. |
|--|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|

## Physical Examination Notes

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|--|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|  | Assess neonates for hypothermia and hypoglycemia; warm hypothermic patients prior to feeding; fleas are common and manual removal is safest; in climbing species, facial, nasal, pelvic, and spinal trauma are common from falls.                                                                                                                                                                                 |
|  | Age determination of squirrels: newborn—body pink and hairless, eyes and ears sealed; 1-2 wk—hair growth begins, skin color darkens, eyelids obvious; 2-3 wk—fur coloration takes on adult pattern, lower incisors erupt; 3-4 wk—eye slits begin to open at corners; 4-5 wk—eyes open; 5-6 wk—upper incisors erupt, ears open; 6-7 wk—weaning occurs in ground squirrels; 10 wk—weaning occurs in tree squirrels. |

## Venipuncture Sites

|  |                                                                                                                                                                                                                       |
|--|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|  | Small rodents often require cranial vena cava venipuncture under anesthesia; larger species have accessible jugular veins, cephalic veins, and medial and lateral saphenous veins; beavers have accessible tail vein. |
|--|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|

## Fluid Administration

|  |                                                                                                                                                                                         |
|--|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|  | Neonatal patients and adults of small species require SC or PO administration. Adults of larger species may tolerate a cephalic or saphenous catheter if in a compromised mental state. |
|  | Maintenance fluid rate 50-100 ml/kg/day.                                                                                                                                                |

## Release Tips

|  |                                                                                                                                                                               |
|--|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|  | Release squirrels at 12-14 (occasionally 10) wk. Release woodchucks and marmots at 14-16 wk. Release early in the day in an area with brush for hiding or trees for climbing. |
|--|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|

## Commonly Used Medication

Improper antibiotic therapy causes gastric dysbiosis. Avoid narrow spectrum antimicrobials such as amoxicillin, penicillin, ampicillin, clindamycin, lincomycin, erythromycin, and cephalosporins. See rodent chapter ([Chapter 8](#)) for pharmacology information.

<sup>a</sup> Although this outline is intended to provide general guidelines for the care of injured wildlife, the veterinarian is strongly encouraged to transfer these animals to experienced rehabilitators as soon as possible and/or to contact rehabilitators if questions arise. In addition, any individual working with wildlife should check with state and federal officials on permit requirements.

<sup>b</sup> In order to prevent aggressive behavior between individuals, avoid housing weaned squirrels together in the same enclosure if they were not introduced prior to weaning.

TABLE 13-6 Recommendations for the Captive Management of Birds of Prey. [1,5,10,15,16,28-30,41,42](#)

| Topic                         | Notes <sup>a</sup>                                                                                                                                                                                                                                                                                                                                                                                                                               |
|-------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Species Identification</b> |                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
|                               | Many field guides exist for birds of prey, including: <i>Sibley Birds of North America</i> , <sup>42</sup> <i>Peterson Field Guides—Hawks</i> , <sup>5</sup> and <i>National Geographic Field Guide to the Birds of North America</i> . <sup>30</sup> Also, see the Cornell Ornithology Lab's Birds of North America online: <a href="http://bna.birds.cornell.edu/bna/">http://bna.birds.cornell.edu/bna/</a> .                                 |
| <b>Feeding Guidelines</b>     |                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
| Nestling                      | Hand-feed with an adult conspecific puppet or blunted end tweezers. Cover person's head and body with a sheet or disguise to prevent imprinting. Feed small pieces of furless, chopped prey soaked in water to increase moisture content. Feed until satiated 3-4×/day. Feed approximately 20-25% body weight. Hatchlings require 2-3 times the amount required by an adult. Be sure food does not rest on top of glottis to avoid asphyxiation. |
| Fledgling                     | Start by hand-feeding as with nestling. Once eating well, offer whole prey chopped into small pieces on a flat plate in the morning prior to hand-feedings to give patient the opportunity to eat on own volition. Once patient is eating without assistance, gradually increase food size until offering whole prey items. Young raptors cannot tear whole prey until fully developed. Feed approximately 20-25% body weight per day.           |
| Adult                         | Feed most raptors once daily in the morning. Feed owls in the evening. Animals with poor appetite may have more interest in whole prey chopped into bite-size pieces or prey sliced open to expose the viscera.                                                                                                                                                                                                                                  |
|                               | Owls, hawks, falcons: <0.5 kg; offer 1 mouse per day.                                                                                                                                                                                                                                                                                                                                                                                            |
|                               | Owls, hawks, falcons: 0.5–1.5 kg; offer 2-3 mice, ½—1 rat, 2 chicks, or ½ quail per day.                                                                                                                                                                                                                                                                                                                                                         |

|  |                                                                          |
|--|--------------------------------------------------------------------------|
|  | Eagles: 1 large rat, 8 mice, or 1 medium sized fish (250-300 g) per day. |
|--|--------------------------------------------------------------------------|

|  |                                                  |
|--|--------------------------------------------------|
|  | Osprey: 1 medium sized fish (200-275 g) per day. |
|--|--------------------------------------------------|

|  |                                                                                                                                                              |
|--|--------------------------------------------------------------------------------------------------------------------------------------------------------------|
|  | Vultures: skin food prior to administration to prevent trichobezoars. Feed 5 mice, 1 rat, or 1 medium sized fish per day. Slice food open to expose viscera. |
|--|--------------------------------------------------------------------------------------------------------------------------------------------------------------|

|  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
|--|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|  | The above recommendations are based on years of rehabilitation experience and may be used as a starting point. Energy requirements for raptors may also be determined by calculating the basal metabolic rate ( $BMR = k \times BW^{0.75}$ ; $k = 78$ , $BW = \text{kg}$ ) and the maintenance energy requirements ( $MER = \text{Energy Requirements} \times BMR$ ; energy requirements: starvation = 0.6, mild trauma = 1.1, severe trauma = 1.5-2, growth = 2.5, sepsis = 1.5, burns = 2). A typical mouse is 55-65 kcal. |
|--|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|

|  |                                                                                                                                                                               |
|--|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|  | Frozen fish should be supplemented with vitamins such as VitaHawk (DB Scientific) or Sea Tabs (Pacific Research Laboratories) to correct for potentially low thiamine levels. |
|--|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|

## Critical Care

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|--|-------------------------------------------------------------------------|
|  | See Figure 13-1 for raptor fluid resuscitation and refeeding algorithm. |
|--|-------------------------------------------------------------------------|

|  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
|--|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|  | When tube feeding, divide total daily formula into 2 (preferred) to 4 feedings with maximum volume per feeding: 40 mL/kg or 5% of body weight. Administer formula with red rubber catheter into crop as last procedure before returning patient to cage to reduce risk of regurgitation. During feeding, monitor closely for regurgitation. If regurgitation occurs, stop immediately, clean oral cavity with cotton-tipped applicators, and reduce next feeding volume. |
|--|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|

## Indoor Housing

|  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
|--|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|  | House standing patients in a crate or solid-wall cage with newspaper on the bottom and a sturdy perch to stand upon; cover front door with towel and keep in quiet room; a protective tailguard should be placed on all raptors with tails long enough to bump cage sides or cage flooring to prevent feather damage that could affect flight and delay release. If housed for extended periods, a rotation of perches of variable texture should be provided to prevent pododermatitis (examples of perch coverings include Astroturf, hemp rope, and natural wood/bark). Nestlings and fledglings may need a perch and a doughnut-shaped nest formed from towels/sheets. It is normal for nestlings and fledglings to sleep in sternal recumbency. Adult recumbent patients should be supported in an upright position by rolling towels and creating a doughnut-shaped support surrounding patient body. Critical patients may be kept in incubator at 80-85°F (26.7-29.4°C) and given supplemental oxygen. All raptors should be transferred to experienced rehabilitators as soon as possible for continued treatment and flight conditioning prior to release. |
|--|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|

## Safe Handling and Restraint

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|--|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|  | Appropriate protective gear includes leather gloves (garden gloves for small species and up to the elbows or higher for larger hawks and eagles) and protective eyewear. A leather welder's jacket may be used for large raptors such as eagles. Raptors will use talons for primary defense but may also use their beak. Restrain feet first and head second. A body grab should be used if the bird has a known leg injury. A towel may be placed over body prior to restraint to reduce wing flapping. Vulture defense includes regurgitation. Keeping patient neck extended will reduce regurgitation efforts. Keep patient eyes covered with a hood or light cloth during handling to reduce patient stress. |
|--|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|

## Physical Examination Notes

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|--|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|  | <p>Always examine the fundic portion of the eye as ocular lesions are common findings in raptors with trauma, including chorioretinal tears and pecten hemorrhage. Clavicle and coracoid fractures palpable in the thoracic inlet often occur with impact injuries. Asymmetrical wing holding (wing droop) indicates musculoskeletal or neurological injury. Pododermatitis (bumblefoot) is common with extended periods on the ground or inappropriate perching and exercise regimes in captivity. Oral plaques may be caused by a number of conditions including trichomoniasis, <i>Capillaria</i> sp, <i>Candida albicans</i>, electric shock, physical trauma, mixed bacterial infections, aspergillosis, herpes virus, avian poxvirus, or hypovitaminosis.</p> |
|--|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|

|                           |  |
|---------------------------|--|
| <b>Venipuncture Sites</b> |  |
|---------------------------|--|

|  |                                                                                                                             |
|--|-----------------------------------------------------------------------------------------------------------------------------|
|  | Jugular vein (right is larger), basilic vein in either wing, medial metatarsal vein (use caution when working near talons). |
|--|-----------------------------------------------------------------------------------------------------------------------------|

|                             |  |
|-----------------------------|--|
| <b>Fluid Administration</b> |  |
|-----------------------------|--|

|  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
|--|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|  | Intraosseus catheter placement in distal ulnar condyle or proximal tibiotarsus (avoid pneumatic bones such as humerus and femur); IV catheter in medial metatarsal vein, basilic vein, jugular vein; SC in inguinal/prefemoral skin fold where the inner thigh meets the body is preferred; be sure to avoid entering the coelomic cavity and air sac system; give oral fluids only in patients that maintain an upright position and have a functional GI tract to avoid regurgitation and aspiration. |
|--|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|

|  |                              |
|--|------------------------------|
|  | Maintenance 60-100 mL/kg/day |
|--|------------------------------|

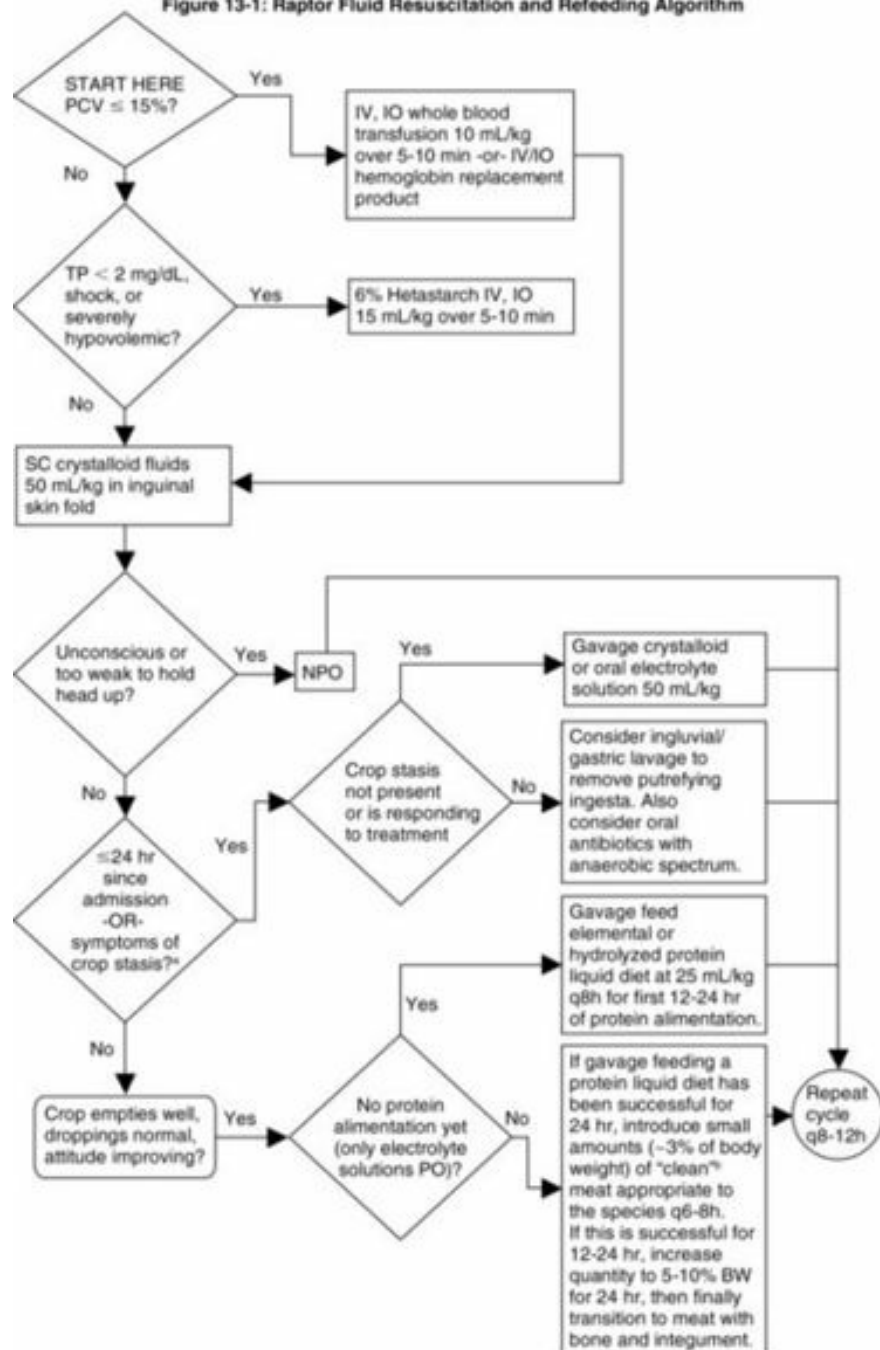
|  |                               |
|--|-------------------------------|
|  | Hetastarch 10-15 mL/kg IV q8h |
|--|-------------------------------|

|                     |  |
|---------------------|--|
| <b>Release Tips</b> |  |
|---------------------|--|

|  |                                                                                                                                                                                                                    |
|--|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|  | Morning release is appropriate for most birds. Release owls in the evening. Release in a suitable habitat for the species. Migratory species may need to be kept over winter if not ready for release in the fall. |
|--|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|

<sup>a</sup> Although this outline is intended to provide general guidelines for the care of injured wildlife, the veterinarian is strongly encouraged to transfer these animals to experienced rehabilitators as soon as possible and/or to contact rehabilitators if questions arise. In addition, any individual working with wildlife should check with state and federal officials on permit requirements.

Figure 13-1: Raptor Fluid Resuscitation and Refeeding Algorithm



\*Symptoms of crop (or gastric) stasis include failure of the crop to empty over several hours, foul breath, lethargy, and/or scant feces.  
 †"Clean" meat is meat that is stripped of bone and integument.  
 Created by Scott Ford, DVM, Dipl ABVP-Avian, Avian Specialty Veterinary Services of Alaska.

TABLE 13-7 Recommendations for the Captive Management of Altricial Wild Birds (Passerines, Woodpeckers, Doves, etc.). [7,13,16,22,24,28,29,39,40](#)

| Topic           | Notes <sup>a,b</sup>                                                                                                                                                               |
|-----------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Age/Diet</b> |                                                                                                                                                                                    |
| Hatchling       | No feathers or small amount of down; bulbous body; frail appendages, unable to sit up; eyes closed. Feed every 15 min if gaping from 7 am-9 pm.                                    |
| Nestling        | Pin feathers show; visible naked areas on the body; downy feathers on head; no tail or only pin feathers; cannot perch; eyes open. Feed every 20-30 min from 7 am-9 pm.            |
| Fledgling       | Feathered; short tail feathers; first attempts to fly; can perch and hop independently; will preen. Feed every 40 to 60 min, from 7 am to 9 pm in addition to offering free choice |

|                                   |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
|-----------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                                   | food.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
| Adult                             | Feathered; defensive behavior; able to fly; juveniles often are still fed by parents. Provide juveniles hand feeding every 2-4 hr, 7 am-9 pm, in addition to free-choice food until they are self-feeding. If not self-feeding, adults will require gavage feeding or hand-feeding.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| <b>Critical Care</b>              |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
|                                   | Energy requirements may be determined by calculating the basal metabolic rate ( $BMR = k \times BW^{0.75}$ ; $k = 129$ , $BW$ = body weight in kg) and the maintenance energy requirements ( $MER = \text{Energy Requirements} \times BMR$ ; energy requirements: starvation = 0.6, mild trauma = 1.1, severe trauma = 1.5-2; growth = 2.5; sepsis = 1.5, burns = 2).                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
|                                   | Divide total formula needed per day into 2-4 feedings per day with maximum volume per feeding: 5% of body weight for most birds, 10% of body weight for doves. Ensure the crop is almost empty before the next feeding. Administer formula with metal gavage tube or small rubber feeding tube into crop as last procedure before returning patient to cage to reduce regurgitation risk.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |
| <b>Housing</b>                    |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
|                                   | Keep hatchlings and nestlings in a curved nest-like bed to prevent splay-leg deformities. Maintain incubator at 80-90°F (26-32°C). Give fledglings nest and areas to walk and perch in an incubator at 70-80°F (21-26°C). Keep juveniles and adults in cages with branches, easily cleaned substrate, and quiet surroundings to reduce stress. Cover cages with a thin sheet to reduce stress and cage trauma. Juveniles learning to fly should be provided enough room to exercise. Enclosures should have soft sides to avoid feather damage. Injured or ill adults that cannot stand should be placed in a nest-shaped bed to keep them upright. Maintain adult enclosure at 70-80°F (21-26°C). Woodpeckers and sapsuckers have long tongues with lateral barbs. The barbs may catch in fabric (such as towels) and cause tongue avulsion. House these species with newspaper substrate and nests to prevent injury. |
| <b>Safe Restraint</b>             |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
|                                   | Appropriate protective gear includes light leather gloves. Patients may become stressed or overheat with handling. Watch patient closely and perform procedures in stages if needed. Secure smaller birds using fore and middle fingers around the base of the head and the bird's back pressed against your palm. Do not compress the body by grasping too tightly as this may compromise breathing. Cup doves, pigeons, and similar species in a light towel.                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
| <b>Physical Examination Notes</b> |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
|                                   | Wing droop most often indicates musculoskeletal or neurological injury. Clavicle, scapula, and coracoid fractures are common with impact injuries and may be characterized by the ability to fly horizontally but not vertically. Closely inspect any predatory attack patients for puncture wounds and consider prophylactic antibiotic treatment for cat attack victims. Ocular crusting and nasal discharge are common signs with <i>Mycoplasma</i> disease in finch species. Avian poxvirus lesions are common on unfeathered areas. West Nile virus can present with neurological symptoms, especially in crows and other corvids, but symptoms may be vague in other species.                                                                                                                                                                                                                                     |
|                                   |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
|                                   | Right jugular vein; basilic vein in larger birds is an alternative site                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |



|                             |                                                                                                                                                                                                                                                                                          |
|-----------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Fluid Administration</b> |                                                                                                                                                                                                                                                                                          |
|                             | In small patients, fluid administration may be limited to PO or SC administration in the prefemoral skin fold where the hind limb meets the body. Larger patients can receive IO catheter placement in distal ulnar condyle or proximal tibiotarsus. Maintenance rate: 75-100 mL/kg/day. |
| <b>Release Tips</b>         |                                                                                                                                                                                                                                                                                          |
|                             | Release diurnal species in the morning in a region with plentiful food and areas with cover to avoid predators. Release nocturnal species at sunset.                                                                                                                                     |

<sup>a</sup> Although this outline is intended to provide general guidelines for the care of orphaned wildlife, the veterinarian is strongly encouraged to transfer these animals to experienced rehabilitators as soon as possible and/or to contact rehabilitators if questions arise. In addition, any individual working with wildlife should check with state and federal officials on permit requirements.

<sup>b</sup> Refer to Appendices 99-101 of the 3rd ed of the *Exotic Animal Formulary*<sup>4</sup> for appropriate diet recommendations.

References

1. Arent LR. *Raptors in Captivity*. Blaine, WA: Hancock House Publishers; 2007.
2. Beckwith S. Rehabilitation of orphan river otters. *Nat Wildl Rehab Symp*. 2003;21:51–60.
3. Bekoff M, Jamieson R. Physical development in coyotes (*Canis latrans*) with a comparison to other canids. *J Mam*. 1975;56:685–692.
4. Carpenter JW. *Exotic Animal Formulary*, 3rd ed. St Louis: Saunders/Elsevier; 2005.
5. Clark WS, Wheeler BK. *Peterson Field Guides—Hawks*. New York: Houghton Mifflin Co; 1987.
6. Derrell CJ, Olfert ED. Rodents. In: Fowler ME, ed. *Zoo and Wild Animal Medicine*. 2nd ed. Philadelphia: WB Saunders Co; 1986:727–747.
7. Evans RH. Care and feeding of orphan mammals and birds. In: Kirk RB, ed.

*Current Veterinary Therapy IX: Small Animal Practice*. Philadelphia: WB Saunders Co; 1986:775–787.

8. Fairbrother A, Locke LN, Hoff GL. *Noninfectious Diseases of Wildlife*, 2nd ed, Ames: Iowa State University Press, 1996.

9. Fowler ME, Cubas ZS. *Biology, Medicine, and Surgery of South American Wild Animals*. Ames: Iowa State University Press, 2001.

10. Fowler ME, Miller RE. *Zoo and Wild Animal Medicine*, 5th ed, St Louis: WB Saunders Co, 2003.

11. Fox Valley Animal Nutrition. Inc. (Lake Zurich, IL). Web site. Available at <http://www.foxvalleynutrition.com/main/home.asp>, Jan 10, 2011. Accessed

12. Gage LJ. *Hand-Rearing Wild and Domestic Mammals*. Ames: Iowa State University Press; 2002.

13. Gage LJ, Duerr RS. *Hand-Rearing Birds*. Ames: Blackwell Publishing; 2007.

14. Gamble KC. Marsupial care and husbandry. *Vet Clin North Am Exotic Anim Pract*. 2004;7:283–298.

15. Graham JE, Heatley JJ. Emergency care of raptors. *Vet Clin North Am Exotic Anim Pract*. 2007;10:395–418.

16. Harrison GJ, Lightfoot TL. *Clinical Avian Medicine*. Palm Beach: Spix Publishing, 2006.

17. Hill's Pet Nutrition. Inc. (Topeka, KS) Web site. Available at <http://www.hillspet.com>, Jan 19, 2011. Accessed

18. Jackson DL, Gluesing EA, Jacobson HA. Dental eruption in bobcats. *J Wildl Manage*. 1988;52:515–517.

19. Johnson V, Adams P, Goodrich P, et al. *Wild Animal Care and Rehabilitation Manual*. Kalamazoo: Beech Leaf Press; 1991.

20. Johnson-Delaney CA. What every veterinarian needs to know about Virginia opossums. *Exotic DVM*. 2005;6:38–43.
21. Lafeber Company (Cornell IL). Web site. Available at <http://www.lafebervet.com>, Jan 14, 2011. Accessed
22. Lambert Kay (Kansas CityMO) Web site. Mother's Helper puppy formula mix. Available at <http://www.lambertkay.com>, Jan 18, 2011. Accessed
23. Linhart SB. Dentition and pelage in the juvenile red fox (*Vulpes vulpes*). *J Mam*. 1968;49:526–528.
24. Luther E. *Answering the Call of the Wild*. Toronto: Toronto Wildlife Center; 2010.
25. Marcum D. Rehabilitation of North American Wild Mammals. Feeding and Nutrition. Suisan, CA: International Wildlife Rehabilitation Council; 1997.
26. Mazuri (St Louis MO) Web site. Mazuri Exotic Feline diet. Available at <https://www.mazuri.com>, Jan 11, 2011. Accessed
27. McRuer DL, Jones KD. Behavioral and nutritional aspects of the Virginian opossum (*Didelphis virginiana*). *Vet Clin North Am Exotic Anim Pract*. 2009;12:217–236.
28. Mitchell MA, Tully T, Jr. *Manual of Exotic Pet Practice*. St Louis: Saunders/Elsevier, 2009.
29. Moore AT, Joosten S. *Principles of Wildlife Rehabilitation*. St Cloud, MN: National Wildlife Rehabilitation Association; 1997.
30. National Geographic Society. *National Geographic Field Guide to the Birds of North America*, 2nd ed. Washington, DC: National Geographic Society; 1999.
31. Nelson R, Couto CG. *Small Animal Internal Medicine*, 2nd ed, St Louis: Mosby, 1998.
32. Nowak RM. *Walker's Mammals of the World*, 6th ed. Baltimore: The Johns

Hopkins University Press; 1999.

33. Oxbow Animal Health (Murdock, NE) Web site. Available at <http://www.oxbowanimalhealth.com>, Jan 14, 2011. Accessed
34. Paul-Murphy J. Critical care of the rabbit. *Vet Clin North Am Exotic Anim Pract.* 2007;10:437–461.
35. Pedialyte Columbus, OH) Web site. Pedialyte. Available at <http://pedialyte.com/>, Jan 19, 2011. Accessed
36. PetAg Hampshire, IL) Web site. Zoologic milk matrix formulation and mixing guide. Available at <http://www.petag.com/zoologic.asp>, Jan 10, 2011. Accessed
37. Quesenberry KE, Carpenter JW. Ferrets, Rabbits, and Rodents. Clinical Medicine and Surgery. 2nd ed. St Louis: WB Saunders Co; 2004.
38. Reed-Smith J, Ball J. *North American River Otter Husbandry Notebook*, 2nd ed. Grand Rapids: John Ball Zoological Garden; 2001.
39. Reptarium Web site. Available at <http://www.reptarium.com/>, Jan 18, 2011. Accessed
40. Samour JH, ed. *Avian Medicine*, 2nd ed, Philadelphia: Mosby Elsevier, 2008.
41. Scott D. *Raptor Rehabilitation*. Raleigh: Lulu; 2010.
42. Sibley DA. *Sibley Birds of North America*. New York: Alfred A Knopf, Inc; 2000.
43. UPCO (St Louis, MO) Web site. Available at <http://www.upco.com/>, Jan 20, 2011. Accessed
44. Williams ES, Barker IK. *Infectious Diseases of Wild Mammals*, 3rd ed, Ames: Iowa State University Press, 2001.



Appendices

Selected topics for the exotic animal veterinarian

Julie Swenson, James W. Carpenter

TABLE A-1 Classification of Select Antimicrobials Used in Exotic Animal Medicine.

| Type                                          | Antimicrobial Agent     |
|-----------------------------------------------|-------------------------|
| Benzyl penicillins <sup>a</sup>               | Benzathine penicillin G |
|                                               | Procaine penicillin G   |
| Extended-spectrum penicillins <sup>a</sup>    |                         |
| Aminopenicillins                              | Amoxicillin             |
|                                               | Ampicillin              |
| Antipseudomonal penicillins                   |                         |
| Carboxypenicillins                            | Carbenicillin           |
|                                               | Ticarcillin             |
| Piperazine penicillins                        | Piperacillin            |
| Carbapenems <sup>b</sup>                      | Imipenem                |
|                                               | Meropenem               |
| β-lactamase inhibitors                        | Ampicillin/sulbactam    |
|                                               | Piperacillin/tazobactam |
| Clavulanic acid                               | Amoxicillin/clavulanate |
|                                               | Ticarcillin/clavulanate |
| First-generation cephalosporins <sup>a</sup>  | Cefadroxil              |
|                                               | Cefazolin               |
|                                               | Cefovecin               |
|                                               | Cephalexin              |
|                                               | Cepodoxime              |
| Third-generation cephalosporins <sup>a</sup>  | Cefixime                |
|                                               | Cefotaxime              |
|                                               | Ceftazidime             |
|                                               | Ceftiofur               |
| Fourth-generation cephalosporins <sup>a</sup> | Cefepime                |
|                                               | Cefpirome               |

|                                                  |                               |
|--------------------------------------------------|-------------------------------|
| Macrolides <sup>b</sup>                          | Clarithromycin                |
|                                                  | Erythromycin                  |
|                                                  | Tilmicosin                    |
|                                                  | Tylosin                       |
| Azalides                                         | Azithromycin                  |
| Ketolides <sup>b</sup>                           | Telithromycin                 |
| Tetracyclines <sup>b</sup>                       | Chlortetracycline             |
|                                                  | Doxycycline                   |
|                                                  | Oxytetracycline               |
|                                                  | Tetracycline                  |
| Chloramphenicol (or its derivative) <sup>b</sup> | Chloramphenicol               |
|                                                  | Florfenicol                   |
| Lincosamides <sup>c</sup>                        | Clindamycin                   |
|                                                  | Lincomycin                    |
|                                                  | Pirlimycin                    |
| Aminoglycosides <sup>a</sup>                     | Amikacin                      |
|                                                  | Gentamicin                    |
|                                                  | Kanamycin                     |
|                                                  | Neomycin                      |
|                                                  | Streptomycin                  |
|                                                  | Tobramycin                    |
| Aminocyclitols <sup>b</sup>                      | Spectinomycin                 |
| Nitroimidazole <sup>d</sup>                      | Metronidazole                 |
|                                                  | Ronidazole                    |
| Sulfonamides <sup>b</sup>                        | Sulfachlorpyridazine          |
|                                                  | Sulfadiazine                  |
|                                                  | Sulfadimethoxine              |
|                                                  | Sulfamethazine                |
|                                                  | Sulfamethoxazole              |
|                                                  | Sulfaquinoxaline              |
|                                                  | Sulfathiazole                 |
|                                                  | Sulfisoxazole                 |
| Trimethoprim <sup>a</sup>                        | Trimethoprim                  |
| Trimethoprim/sulfas <sup>a</sup>                 | Trimethoprim/sulfadiazine     |
|                                                  | Trimethoprim/sulfamethoxazole |
| Quinolones <sup>b</sup>                          | Nalidixic acid                |
|                                                  |                               |

|                               |               |
|-------------------------------|---------------|
| Fluoroquinolones <sup>a</sup> | Ciprofloxacin |
|                               | Danofloxacin  |
|                               | Difloxacin    |
|                               | Enrofloxacin  |
|                               | Marbofloxacin |
|                               | Orbifloxacin  |

<sup>a</sup> Bactericidal.

<sup>b</sup> Bacteriostatic.

<sup>c</sup> Bacteriostatic or bactericidal.

<sup>d</sup> Cidal vs. amoebae, *Giardia*, *Trichomonas*, and most obligate anaerobes; inactive vs. most aerobic bacteria or facultative anaerobes.

TABLE A-2 General Efficacy of Select Antimicrobial Agents Used in Exotic Animals.

| Infectious Agent                    | Antimicrobial Agent                                                                                                                                                                                                                                                                                                                                                        |
|-------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Gram-positive bacteria              |                                                                                                                                                                                                                                                                                                                                                                            |
| Gram-positive bacteria (in general) | <ul style="list-style-type: none"> <li>• Aminoglycosides (select) (amikacin, gentamicin)</li> <li>• Azalides (i.e., azithromycin)</li> <li>• Cephalosporins</li> <li>• Chloramphenicol</li> <li>• Erythromycin</li> <li>• Florfenicol</li> <li>• Fluoroquinolones</li> <li>• Lincosamides</li> <li>• Macrolides</li> <li>• Penicillins</li> <li>• Tetracyclines</li> </ul> |



|                           |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
|---------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <i>Staphylococcus</i> spp | <ul style="list-style-type: none"><li>• Aminoglycosides (select) (amikacin, gentamicin)</li><li>• Azithromycin</li><li>• <math>\beta</math>-lactams (early-generation)</li><li>• Cephalosporins (cefpodoxime, cefovecin)</li><li>• Chloramphenicol</li><li>• Clindamycin</li><li>• Fluoroquinolones</li><li>• Lincosamides</li><li>• Macrolides</li><li>• Penicillin/<math>\beta</math>-lactamase inhibitor (ampicillin/sulbactam, amoxicillin/clavulanate, piperacillin/tazobactam, ticarcillin/clavulanate)</li><li>• Trimethoprim/sulfas</li></ul> |
| <i>Streptococcus</i> spp  | <ul style="list-style-type: none"><li>• Azithromycin</li><li>• <math>\beta</math>-lactams (early-generation)</li><li>• Cephalosporins</li><li>• Chloramphenicol</li><li>• Clindamycin</li><li>• Lincosamides</li><li>• Macrolides</li><li>• Penicillins</li><li>• Tetracyclines</li><li>• Trimethoprim/sulfas</li></ul>                                                                                                                                                                                                                               |
|                           | <ul style="list-style-type: none"><li>• Azithromycin</li><li>• Cephalosporins (cefotetan, cefoxitin)</li></ul>                                                                                                                                                                                                                                                                                                                                                                                                                                        |

|                                            |                                                                                                                                                                                                                                                                                                 |
|--------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <i>Clostridium</i> spp and other anaerobes | <ul style="list-style-type: none"> <li>• Chloramphenicol</li> <li>• Clindamycin</li> <li>• Erythromycin</li> <li>• Florfenicol</li> <li>• Lincomycin</li> <li>• Metronidazole<sup>a</sup></li> <li>• Penicillins (amoxicillin/clavulanate)</li> <li>• Tetracyclines</li> </ul>                  |
| <b>Gram-negative bacteria</b>              |                                                                                                                                                                                                                                                                                                 |
| Enterobacteriaceae (in general)            | <ul style="list-style-type: none"> <li>• Aminoglycosides (amikacin, gentamicin)</li> <li>• Azalides</li> <li>• Carbapenems</li> <li>• Cephalosporins (third/fourth-generation)</li> <li>• Fluoroquinolones</li> <li>• Penicillins (extended-spectrum)</li> <li>• Trimethoprim/sulfas</li> </ul> |
| <i>Campylobacter</i> spp                   | <ul style="list-style-type: none"> <li>• Amoxicillin</li> <li>• Azithromycin</li> <li>• Ceftriazone</li> <li>• Chloramphenicol</li> <li>• Clindamycin</li> <li>• Doxycycline</li> <li>• Erythromycin</li> <li>• Fluoroquinolones</li> </ul>                                                     |

|                                               |                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
|-----------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                                               | <ul style="list-style-type: none"><li>• Furazolidone</li><li>• Gentamicin</li><li>• Neomycin</li></ul>                                                                                                                                                                                                                                                                                                                                                                  |
| <i>Pasteurella</i> spp (resistance may occur) | <ul style="list-style-type: none"><li>• Aminoglycosides (amikacin, gentamicin)</li><li>• Chloramphenicols (chloramphenicol, florfenicol)</li><li>• Erythromycin</li><li>• Fluoroquinolones</li><li>• Penicillins</li><li>• Sulfonamides</li><li>• Trimethoprim/sulfas</li><li>• Tetracyclines</li></ul>                                                                                                                                                                 |
| <i>Pseudomonas</i> spp (often resistant)      | <ul style="list-style-type: none"><li>• Aminoglycosides (frequently in combination with an advanced-generation <math>\beta</math>-lactam)</li><li>• Carbapenems</li><li>• Ceftazidime and fourth-generation cephalosporins (frequently in combination with an aminoglycoside)</li><li>• Chloramphenicol</li><li>• Fluoroquinolones</li><li>• Penicillins (advanced-generation) (carbenicillin, ticarcillin; frequently in combination with an aminoglycoside)</li></ul> |
| <i>Salmonella</i> spp                         | <ul style="list-style-type: none"><li>• Aminoglycosides</li><li>• Chloramphenicol</li><li>• Fluoroquinolones</li><li>• Penicillins (advanced-generation)</li><li>• Trimethoprim/sulfas</li></ul>                                                                                                                                                                                                                                                                        |

|                                |                                                                                                                                                                                                                   |
|--------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <i>Chlamydia/Chlamydophila</i> | <ul style="list-style-type: none"> <li>• Azithromycin</li> <li>• Enrofloxacin (vs. some species)</li> <li>• Erythromycin</li> <li>• Tetracyclines (doxycyline)</li> </ul>                                         |
| <i>Mycoplasma spp</i>          | <ul style="list-style-type: none"> <li>• Azithromycin</li> <li>• Chloramphenicol</li> <li>• Clindamycin</li> <li>• Enrofloxacin</li> <li>• Lincosamides</li> <li>• Macrolides</li> <li>• Tetracyclines</li> </ul> |

<sup>a</sup> Effective vs. most obligate anaerobes; inactive vs. most aerobic bacteria or facultative anaerobes.

TABLE A-3 Antimicrobial Therapy Used in Exotic Animals According to Site of Infection.<sup>a,b</sup>

| Site of Infection      | Antimicrobial Agent                                                                  |
|------------------------|--------------------------------------------------------------------------------------|
| Bacteremia, septicemia |                                                                                      |
| Aerobic bacteria       | Aminoglycoside with a penicillin or cephalosporin                                    |
|                        | Cephalosporins (third-generation)                                                    |
|                        | Enrofloxacin with amoxicillin                                                        |
|                        | Penicillins (penicillin, amoxicillin, amoxicillin/clavulanate, ampicillin/sulbactam) |
| Anaerobic bacteria     | Azithromycin                                                                         |
|                        | Cefoxitin, cefotetan                                                                 |

|                       |                                                                                      |
|-----------------------|--------------------------------------------------------------------------------------|
|                       | Chloramphenicol                                                                      |
|                       | Clindamycin                                                                          |
|                       | Florfenicol                                                                          |
|                       | Metronidazole                                                                        |
|                       | Penicillin                                                                           |
| Soft-tissue infection | Azithromycin                                                                         |
|                       | Cephalosporins                                                                       |
|                       | Clindamycin or metronidazole (vs. anaerobes)                                         |
|                       | Enrofloxacin                                                                         |
|                       | Enrofloxacin with metronidazole (vs. polymicrobial aerobic and anaerobic infections) |
|                       | Marbofloxacin                                                                        |
|                       | Penicillin/β-lactamase inhibitor (amoxicillin/clavulanate)                           |
|                       | Tetracyclines                                                                        |
|                       | Trimethoprim/sulfas                                                                  |
| Respiratory tract     | Azithromycin                                                                         |
|                       | Cephalosporins                                                                       |
|                       | Chloramphenicol                                                                      |
|                       | Clindamycin (includes anaerobes)                                                     |
|                       | Enrofloxacin (vs. <i>Mycoplasma</i> , etc.)                                          |
|                       | Florfenicol                                                                          |
|                       | Macrolides (vs. <i>Mycoplasma</i> )                                                  |
|                       | Metronidazole (vs. anaerobes)                                                        |
|                       | Penicillins                                                                          |
|                       | Tetracyclines (vs. <i>Mycoplasma</i> and <i>Chlamydia/Chlamydophila</i> )            |
|                       | Trimethoprim/sulfas                                                                  |
| Alimentary tract      | Amoxicillin                                                                          |
|                       | Cephalosporins                                                                       |
|                       | Enrofloxacin                                                                         |
|                       | Metronidazole (vs. anaerobes)                                                        |
|                       | Neomycin                                                                             |
|                       | Tetracyclines                                                                        |
|                       | Trimethoprim/sulfas                                                                  |
| Skin                  | Amoxicillin/clavulanate                                                              |
|                       | Azithromycin                                                                         |
|                       | Cephalosporins                                                                       |
|                       | Clindamycin                                                                          |
|                       |                                                                                      |

|                        |                                                                      |
|------------------------|----------------------------------------------------------------------|
|                        | Enrofloxacin                                                         |
|                        | Erythromycin                                                         |
|                        | Lincomycin                                                           |
|                        | Marbofloxacin                                                        |
|                        | Trimethoprim/sulfas                                                  |
| Bone and/or joint      | Aminoglycosides                                                      |
|                        | Azithromycin                                                         |
|                        | Cephalosporins                                                       |
|                        | Cephalosporins (third-generation) with clindamycin (vs. anaerobes)   |
|                        | Clindamycin                                                          |
|                        | Fluoroquinolones                                                     |
|                        | Lincosamides                                                         |
|                        | Penicillins (extended-spectrum)                                      |
|                        | Penicillins with clindamycin (vs. anaerobes)                         |
| Urinary tract          | Cephalosporins (cephalexin, cefadroxil, cefazolin)                   |
|                        | Fluoroquinolones                                                     |
|                        | Penicillins (ampicillin, amoxicillin, amoxicillin/clavulanate)       |
|                        | Sulfisoxazole                                                        |
|                        | Tetracyclines                                                        |
|                        | Trimethoprim/sulfas                                                  |
| Central nervous system | Azithromycin                                                         |
|                        | Cephalosporins (third-generation) (excluding cefpodoxime, cefovecin) |
|                        | Chloramphenicol (encephalitis)                                       |
|                        | Florfenicol                                                          |
|                        | Fluoroquinolones (meningitis)                                        |
|                        | Metronidazole (vs. anaerobes)                                        |
|                        | Penicillins (in cases of inflammation)                               |
|                        | Trimethoprim/sulfas                                                  |
|                        |                                                                      |
| Reproductive tract     | Amoxicillin/clavulanate                                              |
|                        | Chloramphenicol                                                      |
|                        | Clindamycin (vs. anaerobes)                                          |
|                        | Enrofloxacin                                                         |
|                        | Florfenicol                                                          |
|                        | Trimethoprim/sulfas                                                  |

<sup>a</sup> Definitive therapy should be based on bacterial culture and sensitivity and host species involved.

<sup>b</sup> Modified from: Allen DG, Pringle JK, Smith D. *Handbook of Veterinary Drugs*. Philadelphia: JB Lippincott Co; 1993; Gilbert DN, Moellering RC Jr, Sande MA. *The Sanford Guide to Antimicrobial Therapy* 2003. 33rd ed. Hyde Park, VT: Antimicrobial Therapy, Inc; 2003; Prescott JF, Baggot JD, Walker RD. *Antimicrobial Therapy in Veterinary Medicine*. Ames: Iowa State University Press; 2000; Greene CE, ed. *Infectious Diseases of the Dog and Cat*. 3rd ed. St. Louis: Saunders/Elsevier; 2006; and Dr. B. Kukanich, personal communication, 2011.

TABLE A-4 Antimicrobial Combination Therapies Commonly Used in Exotic Animals.<sup>a</sup>

| Antimicrobial Agent                                              | Synergistic or Combination Agent                                                                                                                                               |
|------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Aminoglycosides <sup>b</sup><br>(amikacin, gentamicin)           | Cephalosporins, clindamycin, fluoroquinolones, lincomycin, metronidazole, penicillins (carbenicillin, piperacillin, ticarcillin, amoxicillin, ampicillin), trimethoprim/sulfas |
| Amoxicillin                                                      | Clavulanate                                                                                                                                                                    |
| Ampicillin                                                       | Sulbactam                                                                                                                                                                      |
| Cephalosporin                                                    | Aminoglycosides, <sup>b</sup> clindamycin, fluoroquinolones, metronidazole, semi-synthetic penicillins                                                                         |
| Clindamycin                                                      | Aminoglycosides, cephalosporins (third-generation), enrofloxacin, penicillins                                                                                                  |
| Fluoroquinolones<br>(enrofloxacin, ciprofloxacin, marbofloxacin) | Aminoglycosides, <sup>b</sup> cephalosporins (third-generation), clindamycin, metronidazole, penicillins (extended-spectrum)                                                   |
| Lincomycin                                                       | Spectinomycin, aminoglycosides <sup>b</sup>                                                                                                                                    |
| Metronidazole                                                    | Amikacin, azithromycin, carbenicillin, cefazolin, cefotaxime, chloramphenicol, enrofloxacin, gentamicin, marbofloxacin, others as indicated                                    |
| Ormetoprim                                                       | Sulfadimethoxine                                                                                                                                                               |
| Penicillins (carbenicillin, piperacillin, ampicillin)            | Aminoglycosides, <sup>b</sup> fluoroquinolones                                                                                                                                 |
| Penicillins, early generation                                    | Aminoglycosides, <sup>b</sup> third-generation cephalosporins, fluoroquinolones                                                                                                |
| Ticarcillin                                                      | Clavulanate                                                                                                                                                                    |
| Trimethoprim                                                     | Sulfadiazine, sulfamethoxazole                                                                                                                                                 |
| Tylosin                                                          | Oxytetracycline                                                                                                                                                                |

<sup>a</sup> Indicated when synergy is advantageous in definitive therapy, to treat polymicrobial infections, to broaden empiric coverage, or to attempt to prevent the development of antimicrobial resistance.

<sup>b</sup> Generally amikacin, occasionally gentamicin.

TABLE A-5 Select Laboratories Conducting Exotic Animal Diagnostic Procedures.

| Laboratory                                                                                                                                                                                                                                               | Test/Procedure                                                                                                                                                                                                                                                                                                   |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <p>AMR Laboratories</p> <p>PO Box 656</p> <p>Plymouth Meeting, PA 19462 USA</p> <p>(877) 424-1212</p> <p><a href="http://www.amrlabs.com">www.amrlabs.com</a></p>                                                                                        | <p>Avian: Sex determination</p>                                                                                                                                                                                                                                                                                  |
| <p>Animal Health Diagnostic Center</p> <p>College of Veterinary Medicine</p> <p>Cornell University</p> <p>PO Box 5786</p> <p>Ithaca, NY 14852 USA</p> <p>(607) 253-3900</p> <p><a href="http://ahdc.vet.cornell.edu">http://ahdc.vet.cornell.edu</a></p> | <p>General: Chemistry, hematology, histopathology, microbiology, necropsy, parasitology, virology</p> <p>Avian: <i>Chlamydophila</i>, <i>Cryptosporidium</i>, <i>Giardia</i>, <i>Mycoplasma</i>, influenza virus, West Nile virus, blood lead/zinc</p> <p>Reptile: <i>Cryptosporidium</i>, <i>Salmonella</i></p> |
| <p>Antech Diagnostics</p> <p>10 Executive Boulevard</p> <p>Farmingdale, NY 11735 USA</p>                                                                                                                                                                 | <p>General: Chemistry, hematology, microbiology, virology</p> <p>Avian: <i>Mycoplasma</i>, <i>Aspergillus</i>, <i>Chlamydophila</i>, polyomavirus, psittacine beak and feather disease</p>                                                                                                                       |



|                                                                                                                                                                                                                                                |                                                                                                                                                                                                                                                                       |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <p>(800) 745-4725 (West)</p> <p>(800) 872-1001 (East)</p> <p>(800) 341-3440 (Canada)</p> <p><a href="http://www.antechdiagnostics.com">www.antechdiagnostics.com</a></p>                                                                       | <p>virus, West Nile virus, sex determination, blood lead/zinc</p> <p>Mammal: <i>Encephalitozoon</i>, <i>Pasteurella</i>, ferret adrenal panel, ferret distemper titer</p> <p>Reptile: <i>Mycoplasma</i></p>                                                           |
| <p>Avian Biotech International</p> <p>Animal Genetics, Inc.</p> <p>1336 Timberlane Road</p> <p>Tallahassee, FL 32312 USA</p> <p>(800) 514-9672</p> <p>(850) 386-1145</p> <p><a href="http://www.avianbiotech.com">www.avianbiotech.com</a></p> | <p>Avian: <i>Aspergillus</i>, <i>Candida</i>, <i>Chlamydophila</i>, <i>Cryptosporidium</i>, <i>Giardia</i>, <i>Mycobacterium</i>, polyomavirus, psittacine beak and feather disease virus, influenza virus, West Nile virus, Pacheco's disease, sex determination</p> |
| <p>Avian &amp; Exotic Animal Clin Path Labs</p> <p>2712 North Highway 68</p> <p>Wilmington, OH 45177 USA</p> <p>(937) 383-3347</p> <p>(800) 350-1122</p> <p><a href="http://www.avianexoticlab.com">www.avianexoticlab.com</a></p>             | <p>General: Chemistry, hematology, histopathology, microbiology, parasitology, toxicology, virology</p> <p>Avian: <i>Chlamydophila</i>, <i>Cryptosporidium</i>, <i>Giardia</i>, blood iron/lead/zinc</p> <p>Reptile: <i>Cryptosporidium</i></p>                       |
| <p>Avian and Wildlife Laboratory</p> <p>Division of Comparative Pathology</p> <p>University of Miami School of Medicine</p> <p>1611 NW 12<sup>th</sup> Avenue</p> <p>Miami, FL 33136 USA</p>                                                   | <p>General: Chemistry, electrophoresis, hematology</p> <p>Avian: <i>Aspergillus</i>, <i>Chlamydophila</i>, <i>Cryptosporidium</i>, sex determination, polyomavirus, psittacine beak and feather disease</p>                                                           |

|                                                                                                                                                                                                                                                       |                                                                                                                                                                                                                                                                                                                          |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <p>(305) 585-6303</p> <p><a href="http://pathology.med.miami.edu/x133.xml">http://pathology.med.miami.edu/x133.xml</a></p>                                                                                                                            | <p>virus</p>                                                                                                                                                                                                                                                                                                             |
| <p>Bioreliance</p> <p>14920 Broschart Road</p> <p>Rockville, MD USA</p> <p>(800) 553-5372</p> <p><a href="http://www.bioreliance.com">www.bioreliance.com</a></p>                                                                                     | <p>General: Chemistry, hematology, microbiology, parasitology</p> <p>Mammal: <i>Encephalitozoon</i>, <i>Helicobacter</i>, <i>Mycoplasma</i>, Tyzzer's disease</p>                                                                                                                                                        |
| <p>Charles River Labs</p> <p>251 Ballardvale Street</p> <p>Wilmington, MA 01887 USA</p> <p>(877) 274-8371</p> <p><a href="http://www.criver.com">www.criver.com</a></p>                                                                               | <p>General: Chemistry, hematology, microbiology, parasitology</p> <p>Mammal: <i>Helicobacter</i>, <i>Lawsonia intracellularis</i>, <i>Pasteurella</i>, <i>Salmonella</i>, <i>Mycoplasma</i>, Aleutian disease virus, ferret enteric coronavirus, ferret rotavirus, influenza virus</p>                                   |
| <p>Diagnostic Center for Population and Animal Health</p> <p>Michigan State University</p> <p>4125 Beaumont Road</p> <p>Lansing, MI 48910 USA</p> <p>(517) 353-1683</p> <p><a href="http://www.animalhealth.msu.edu">www.animalhealth.msu.edu</a></p> | <p>General: Chemistry, hematology, histopathology, microbiology, necropsy, toxicology, virology</p> <p>Avian: <i>Chlamydophila</i>, <i>Mycoplasma</i>, influenza virus, West Nile virus, blood lead</p> <p>Mammal: Ferret enteric coronavirus, ferret rotavirus</p> <p>Reptile: <i>Mycoplasma</i>, <i>Salmonella</i></p> |
|                                                                                                                                                                                                                                                       | <p>General: Chemistry, endocrinology, hematology, histopathology</p>                                                                                                                                                                                                                                                     |

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|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <p>Diagnostics Services</p> <p>College of Veterinary Medicine</p> <p>University of Tennessee</p> <p>2407 River Drive</p> <p>Knoxville, TN 37996 USA</p> <p>(865) 974-8387</p> <p><a href="http://www.vet.utk.edu/diagnostic">www.vet.utk.edu/diagnostic</a></p>         | <p>microbiology, necropsy, parasitology, toxicology, virology</p> <p>Avian: <i>Aspergillus</i>, <i>Chlamydophila</i>, <i>Cryptosporidium</i>, <i>Giardia</i>, Pacheco’s disease, sex determination, blood lead/zinc</p> <p>Mammal: <i>Encephalitozoon</i>, ferret adrenal panel</p> <p>Reptile: Ophidian paramyxovirus</p>                                                                                                                                                                                                                                                                                                                                     |
| <p>Georgia Veterinary Diagnostic Laboratories</p> <p>College of Veterinary Medicine</p> <p>University of Georgia</p> <p>501 DW Brooks Drive</p> <p>Athens, GA 30602 USA</p> <p>(706) 542-5568</p> <p><a href="http://www.vet.uga.edu/dlab">www.vet.uga.edu/dlab</a></p> | <p>General: Chemistry, hematology, histopathology, microbiology, necropsy, parasitology, toxicology, virology</p> <p>Avian: <i>Aspergillus</i>, <i>Chlamydophila</i>, <i>Cryptosporidium</i>, <i>Mycobacterium</i>, influenza virus, West Nile virus, Pacheco’s disease, blood lead/zinc</p> <p>Mammal: <i>Encephalitozoon</i>, <i>Francisella tularensis</i>, <i>Helicobacter</i>, <i>Mycoplasma</i>, <i>Pasteurella</i>, rabies virus, Sendai virus, Tyzzer’s disease</p> <p>Reptile: <i>Cryptosporidium</i>, <i>Salmonella</i>, adenovirus</p> <p>Aquatic: Aquatic bacterial and fungal cultures (including <i>Mycobacterium</i> and <i>Mycoplasma</i>)</p> |
|                                                                                                                                                                                                                                                                         |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |

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|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <p>Kansas State Veterinary Diagnostic Laboratory</p> <p>College of Veterinary Medicine</p> <p>Kansas State University</p> <p>1800 Denison Avenue</p> <p>Manhattan, KS 66506 USA</p> <p>(866) 512-5650</p> <p><a href="http://www.vet.k-state.edu/depts/dmp/service">www.vet.k-state.edu/depts/dmp/service</a></p> | <p>General: Chemistry, hematology, histopathology, microbiology, necropsy, parasitology, toxicology, virology</p> <p>Avian: <i>Aspergillus</i>, <i>Bordetella</i>, <i>Chlamydophila</i>, <i>Cryptosporidium</i>, influenza virus, West Nile virus, blood lead</p> <p>Mammal: Rabies virus</p> <p>Reptile: <i>Salmonella</i></p> |
| <p>National Veterinary Services Laboratory</p> <p>USDA-APHIS-VS-NVSL</p> <p>PO Box 844</p> <p>Ames, IA 50010 USA</p> <p>(515) 337-7266</p> <p><a href="http://www.aphis.usda.gov/animal_health/lab_info_services/about_nvsl.shtml">www.aphis.usda.gov/animal_health/lab_info_services/about_nvsl.shtml</a></p>    | <p>General: Microbiology, virology</p> <p>Avian: <i>Chlamydophila</i>, <i>Mycobacterium</i>, <i>Mycoplasma</i>, influenza virus, West Nile virus</p> <p>Mammal: <i>Francisella tularensis</i></p> <p>Reptile: <i>Mycoplasma</i>, <i>Salmonella</i></p>                                                                          |
| <p>Northwest ZooPath</p> <p>654 West Main Street</p> <p>Monroe, WA 98272 USA</p> <p>(360) 794-0630</p> <p><a href="http://www.zoopath.com">www.zoopath.com</a></p>                                                                                                                                                | <p>General: Pathology</p>                                                                                                                                                                                                                                                                                                       |
|                                                                                                                                                                                                                                                                                                                   | <p>General: Microbiology, virology</p> <p>Avian: <i>Aspergillus</i>, <i>Bordetella</i>, <i>Candida</i>, <i>Chlamydophila</i>,</p>                                                                                                                                                                                               |

|                                                                                                                                                                                                                                                              |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <p>Research Associates Laboratory</p> <p>14556 Midway Road</p> <p>Dallas, TX 75224 USA</p> <p>(972) 960-2221</p> <p><a href="http://vetdna.com">http://vetdna.com</a></p>                                                                                    | <p><i>Cryptosporidium</i>, gastric yeast, <i>Helicobacter</i>, <i>Mycobacterium</i>, bornavirus, influenza virus, polyomavirus, psittacine beak and feather disease virus, West Nile virus, sex determination</p> <p>Mammal: <i>Encephalitozoon</i>, <i>Helicobacter</i>, <i>Lawsonia intracellularis</i>, <i>Pasteurella</i>, <i>Mycoplasma</i>, Aleutian disease virus</p> <p>Reptile/Amphibian: Chytrid fungus, <i>Cryptosporidium</i>, <i>Mycoplasma</i>, <i>Salmonella</i>, Chelonian herpesvirus, fibropapillomatosis, ranavirus</p> <p>Aquatic: Koi herpes virus, koi pox virus</p> |
| <p>Texas Veterinary Medical Diagnostic Laboratory</p> <p>Texas A&amp;M University</p> <p>1 Sippel Road</p> <p>College Station, TX 77843 USA</p> <p>(979) 845-3414</p> <p>(888) 646-5623</p> <p><a href="http://tvmdl.tamu.edu">http://tvmdl.tamu.edu</a></p> | <p>General: Chemistry, hematology, histopathology, microbiology, necropsy, toxicology, virology</p> <p>Avian: <i>Aspergillus</i>, <i>Chlamydophila</i>, <i>Cryptosporidium</i>, <i>Mycobacterium</i>, <i>Mycoplasma</i>, polyomavirus, psittacine beak and feather disease virus, West Nile virus, Pacheco's disease, blood lead/zinc</p> <p>Mammal: <i>Encephalitozoon</i>, <i>Mycoplasma</i></p> <p>Reptile: <i>Cryptosporidium</i>, <i>Mycoplasma</i>, <i>Salmonella</i></p>                                                                                                            |

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| <p>Veterinary Medical Diagnostic Lab</p> <p>College of Veterinary Medicine</p> <p>University of Missouri</p> <p>PO Box 6023</p> <p>Columbia, MO 65205 USA</p> <p>(573) 882-6811</p> <p><a href="http://vmdl.missouri.edu">http://vmdl.missouri.edu</a></p> | <p>General: Histopathology, microbiology, necropsy, toxicology, virology</p> <p>Avian: <i>Chlamydophila</i>, <i>Mycoplasma</i>, influenza virus, West Nile virus, blood lead/zinc</p> <p>Reptile: <i>Mycoplasma</i>, <i>Salmonella</i></p>                                                                                                                                                                                                                                                                           |
| <p>Veterinary Molecular Diagnostics, Inc</p> <p>5989 Meijer Drive, Suite 5</p> <p>Milford, OH 45150 USA</p> <p>(513) 576-1808</p> <p><a href="http://www.vmdlabs.com">www.vmdlabs.com</a></p>                                                              | <p>General: Molecular diagnostics</p> <p>Avian: <i>Aspergillus</i>, <i>Bordetella</i>, <i>Chlamydophila</i>, <i>Mycobacterium</i>, gastric yeast, <i>Mycoplasma</i>, adenovirus, bornavirus, coronavirus, influenza virus, paramyxovirus, polyomavirus, psittacine beak and feather disease virus, psittacine herpes virus, West Nile virus, sex determination</p> <p>Mammal: <i>Helicobacter</i>, Aleutian disease virus</p> <p>Reptile: <i>Cryptosporidium</i>, <i>Mycoplasma</i>, bearded dragon atadenovirus</p> |
| <p>Wisconsin Veterinary Diagnostic Laboratory</p> <p>University of Wisconsin</p> <p>455 Easterday Ln</p> <p>Madison, WI 53706 USA</p> <p>(608) 262-5432</p>                                                                                                | <p>General: Histopathology, microbiology, necropsy, virology</p> <p>Avian: <i>Bordetella</i>, <i>Chlamydophila</i>, <i>Mycoplasma</i>, influenza virus, polyomavirus, West Nile virus</p>                                                                                                                                                                                                                                                                                                                            |

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|----------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| (800) 608-8387<br><a href="http://www.wvdl.wisc.edu">www.wvdl.wisc.edu</a>                                                                                     | Reptile: <i>Mycoplasma</i> ,<br><i>Salmonella</i>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
| Zoo/Exotic Pathology Service<br>2825 Kovr Drive<br>West Sacramento, CA 95605 USA<br>(916) 725-5100<br><a href="http://www.zooexotic.com">www.zooexotic.com</a> | General: Pathology                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
| Zoogen, Inc<br>1046 Olive Drive, Suite 1<br>Davis, CA 95616 USA<br>(530) 750-5757<br>(800) 955-2473<br><a href="http://www.cgguy.com">www.cgguy.com</a>        | Avian: Sex determination<br>Reptile: Sex determination                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
| Zoologix, Inc<br>9811 Owensmouth Ave<br>Suite 4<br>Chatsworth, CA 91311 USA<br>(818) 717-8880<br><a href="http://www.zoologix.com">www.zoologix.com</a>        | Avian: <i>Aspergillus</i> ,<br><i>Bordetella</i> , <i>Candida</i> ,<br><i>Chlamydophila</i> ,<br><i>Cryptosporidium</i> ,<br><i>Mycobacterium</i> ,<br><i>Mycoplasma</i> , influenza<br>virus, polyomavirus,<br>psittacine beak and feather<br>disease virus, West Nile<br>virus, Pacheco’s disease<br><br>Mammal: <i>Francisella</i><br><i>tularensis</i> , <i>Giardia</i> ,<br><i>Helicobacter</i> , <i>Lawsonia</i><br><i>intracellularis</i> ,<br><i>Mycoplasma</i> , <i>Pasteurella</i> ,<br><i>Salmonella</i> , Aleutian disease<br>virus, rabies virus, Tyzzer’s<br>disease |

|                                                                                                                                                                                                                                                                                               |                                                                                                   |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------|
|                                                                                                                                                                                                                                                                                               | Reptile/amphibian: Chytrid fungus, <i>Cryptosporidium</i> , <i>Mycoplasma</i> , <i>Salmonella</i> |
| Zoo Medicine Service<br>College of Veterinary Medicine<br>University of Florida<br>PO Box 100126<br>Gainesville, FL 32610 USA<br>(352) 392-4700 (ext. 5700)<br><a href="http://www.vetmed.ufl.edu/college/departments/sacs/research">www.vetmed.ufl.edu/college/departments/sacs/research</a> | Reptile: <i>Mycoplasma</i> , adenovirus, herpesvirus, inclusion body disease, paramyxovirus       |

TABLE A-6 Professional Associations for Veterinarians Interested in Exotics.<sup>a</sup>

| Organization                                           | Web Site                                                       |
|--------------------------------------------------------|----------------------------------------------------------------|
| American Association of Wildlife Veterinarians         | <a href="http://www.aawv.net">www.aawv.net</a>                 |
| American Association of Zoo Veterinarians              | <a href="http://www.aazv.org">www.aazv.org</a>                 |
| American Board of Veterinary Practitioners             | <a href="http://www.abvp.com">www.abvp.com</a>                 |
| American College of Zoological Medicine                | <a href="http://www.aczm.org">www.aczm.org</a>                 |
| American Society of Laboratory Animal Practitioners    | <a href="http://www.aslap.org">www.aslap.org</a>               |
| Association of Amphibian and Reptilian Veterinarians   | <a href="http://www.arav.org">www.arav.org</a>                 |
| Association of Avian Veterinarians                     | <a href="http://www.aav.org">www.aav.org</a>                   |
| Association of Exotic Mammal Veterinarians             | <a href="http://www.aemv.org">www.aemv.org</a>                 |
| Association of Primate Veterinarians                   | <a href="http://www.primatevets.org">www.primatevets.org</a>   |
| Association of Sugar Glider Veterinarians              | <a href="http://www.asgv.org">www.asgv.org</a>                 |
| Association of Zoo Veterinary Technicians              | <a href="http://www.azvt.org">www.azvt.org</a>                 |
| British Veterinary Zoological Society                  | <a href="http://www.bvzs.org">www.bvzs.org</a>                 |
| Canadian Association of Zoo and Wildlife Veterinarians | <a href="http://www.cazwv.org">www.cazwv.org</a>               |
| European Association of Zoo and Wildlife Veterinarians | <a href="http://www.eazwv.org">www.eazwv.org</a>               |
| International Association for Aquatic Animal Medicine  | <a href="http://www.iaaam.org">www.iaaam.org</a>               |
| National Wildlife Rehabilitators Association           | <a href="http://www.nwrawildlife.org">www.nwrawildlife.org</a> |

<sup>a</sup> Web sites accessed on November 15, 2010.



TABLE A-7 Exotic Animal Online Resources for Practitioners.<sup>a</sup>

| Site Name                                                 | Web Site                                                                                                               |                                        |
|-----------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------|----------------------------------------|
| American Society for the Prevention of Cruelty to Animals | <a href="http://www.aspca.org">www.aspca.org</a>                                                                       | Co<br>A<br>Co<br>an<br>ca              |
| Amphibian Diseases Home Page                              | <a href="http://www.jcu.edu.au/school/phtm/PHTM/frogs/ampdis.htm">www.jcu.edu.au/school/phtm/PHTM/frogs/ampdis.htm</a> | A<br>fo<br>cu<br>in<br>ar<br>di        |
| Animal Diversity Web                                      | <a href="http://animaldiversity.ummz.umich.edu">http://animaldiversity.ummz.umich.edu</a>                              | Ta<br>fr<br>U<br>M<br>M<br>Z           |
| Armed Forces Institute of Pathology                       | <a href="http://www.afip.org/consultation/vetpath">www.afip.org/consultation/vetpath</a>                               | In<br>nc<br>A<br>of<br>A               |
| Avibase                                                   | <a href="http://avibase.bsc-eoc.org">http://avibase.bsc-eoc.org</a>                                                    | Se<br>da<br>ta<br>in<br>pl<br>th<br>sp |
| Biodidac                                                  | <a href="http://biodidac.bio.uottawa.ca">http://biodidac.bio.uottawa.ca</a>                                            | B<br>re<br>te<br>In<br>lin             |
| BioOne                                                    | <a href="http://www.bioone.org">www.bioone.org</a>                                                                     | Ro<br>cc<br>bi<br>re<br>Co<br>pe       |

|                                                         |                                                                                                                                                                                         |                                                                                                                       |
|---------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------|
| Center for Agricultural Bioscience International        | <a href="http://www.cabi.org">www.cabi.org</a>                                                                                                                                          | Exotic<br>Center for<br>Agricultural<br>Bioscience<br>International                                                   |
| Convention on International Trade in Endangered Species | <a href="http://www.cites.org">www.cites.org</a>                                                                                                                                        | International<br>Convention<br>on<br>Agricultural<br>Bioscience<br>International<br>Trade in<br>Endangered<br>Species |
| The Colyer Institute                                    | <a href="http://www.colyerinstitute.org">www.colyerinstitute.org</a>                                                                                                                    | Colyer<br>Institute                                                                                                   |
| Dental Anatomy                                          | <a href="http://arbl.cvmbs.colostate.edu/hbooks/pathphys/digestion/pregastric/dentalanat.html">http://arbl.cvmbs.colostate.edu/hbooks/pathphys/digestion/pregastric/dentalanat.html</a> | Dental<br>Anatomy                                                                                                     |
| Exotic DVM                                              | <a href="http://www.exoticdvm.com">www.exoticdvm.com</a>                                                                                                                                | Exotic<br>DVM                                                                                                         |
| Exotic Pet Vet Net                                      | <a href="http://www.exoticpetvet.net">www.exoticpetvet.net</a>                                                                                                                          | Exotic<br>Pet<br>Vet<br>Net                                                                                           |
| The Humane Society                                      | <a href="http://www.humanesociety.org">www.humanesociety.org</a>                                                                                                                        | The<br>Humane<br>Society                                                                                              |
| International Species Information System                | <a href="http://www.isis.org">www.isis.org</a>                                                                                                                                          | International<br>Species<br>Information<br>System                                                                     |
|                                                         |                                                                                                                                                                                         | O                                                                                                                     |

|                                                    |                                                                                                                                             |                                                    |
|----------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------|
| International Union for the Conservation of Nature | <a href="http://www.iucn.org">www.iucn.org</a>                                                                                              | de<br>fi<br>sc<br>er<br>de<br>ch<br>Pr<br>IU<br>TI |
| International Veterinary Information System        | <a href="http://www.ivis.org">www.ivis.org</a>                                                                                              | St<br>O<br>bo<br>w<br>m<br>bo                      |
| An Introduction to Ratite Ranching and Medicine    | <a href="http://instruction.cvhs.okstate.edu/kocan/ostrich/ostbk2a1.htm">http://instruction.cvhs.okstate.edu/kocan/ostrich/ostbk2a1.htm</a> | O<br>ra<br>fr<br>St                                |
| ISI Web of Knowledge                               | <a href="http://www.isiwebofknowledge.com">www.isiwebofknowledge.com</a>                                                                    | R<br>cc<br>sc<br>jo<br>ac<br>C<br>pe<br>ex         |
| Medirabbit                                         | <a href="http://www.medirabbit.com">www.medirabbit.com</a>                                                                                  | R<br>ar<br>de                                      |
| The Merck Veterinary Manual                        | <a href="http://www.merckvetmanual.com/mvm/index.jsp">www.merckvetmanual.com/mvm/index.jsp</a>                                              | M<br>M<br>in<br>ar<br>nc<br>ph<br>pa               |
| Pathology of the Domestic Ferret                   | <a href="http://www.afip.org/consultation/vetpath/ferrets/index.html">www.afip.org/consultation/vetpath/ferrets/index.html</a>              | D<br>pa<br>in<br>D<br>W                            |
|                                                    |                                                                                                                                             | D<br>th                                            |

|                                                                                |                                                                                                                                     |                                                                             |
|--------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------|
| PubMed                                                                         | <a href="http://www.pubmed.org">www.pubmed.org</a>                                                                                  | Li<br>M<br>C<br>pe<br>ex                                                    |
| Research<br>Animal<br>Diagnostic<br>Laboratory                                 | <a href="http://www.radil.missouri.edu/teachresources.html">www.radil.missouri.edu/teachresources.html</a>                          | Te<br>re<br>th<br>M<br>in<br>D<br>R<br>ar<br>A<br>Pa<br>C                   |
| Tufts<br>University<br>Open<br>Courseware,<br>Zoological<br>Medicine<br>Course | <a href="http://ocw.tufts.edu/Course/60">http://ocw.tufts.edu/Course/60</a>                                                         | O<br>cc<br>th<br>U<br>C<br>V<br>M<br>Z<br>M                                 |
| University of<br>Pennsylvania<br>Computer<br>Aided<br>Learning                 | <a href="http://research.vet.upenn.edu/Home/tabid/5849/Default.aspx">http://research.vet.upenn.edu/Home/tabid/5849/Default.aspx</a> | C<br>L<br>fr<br>U<br>Pe<br>Sc<br>V<br>M<br>In<br>Sp<br>Pa<br>Sp<br>Re<br>Se |
| USDA<br>APHIS                                                                  | <a href="http://www.aphis.usda.gov">www.aphis.usda.gov</a>                                                                          | U<br>D<br>A<br>A<br>H<br>Se                                                 |
|                                                                                |                                                                                                                                     | M                                                                           |

|                                            |                                                                          |
|--------------------------------------------|--------------------------------------------------------------------------|
| Veterinary Information Network             | <a href="http://www.vin.com">www.vin.com</a>                             |
| Veterinary Partner                         | <a href="http://www.veterinarypartner.com">www.veterinarypartner.com</a> |
| World Organization for Animal Health (OIE) | <a href="http://www.oie.int">www.oie.int</a>                             |

<sup>a</sup> Web sites accessed on November 15, 2010. Please note that Elsevier Inc. and the editor of the *Exotic Animal Formulary* have not reviewed all of the content of the above sites and therefore cannot confirm the accuracy of the information presented.

TABLE A-8 Captive Husbandry Web Sites for Owners of Exotic Animals.<sup>a</sup>

| Category | Site Name                             | Web Site                                                                       | Description                                                                                                                                                     |
|----------|---------------------------------------|--------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Aquatics | American Goldfish Association         | <a href="http://www.americangoldfish.org">www.americangoldfish.org</a>         | Association for goldfish enthusiasts. Includes husbandry and care information.                                                                                  |
|          | Fish Channel                          | <a href="http://www.fishchannel.com">www.fishchannel.com</a>                   | Web site with information on tropical and saltwater aquariums including a large variety of species-specific information.                                        |
|          | Fish Lore                             | <a href="http://www.fishlore.com">www.fishlore.com</a>                         | Tropical fish, freshwater aquarium, and saltwater aquarium information web site.                                                                                |
|          | Fish Tank Guide                       | <a href="http://www.fish-tank-guide.com">www.fish-tank-guide.com</a>           | Web site including information on basic tank care, fish care, and medical information. Also contains some species-specific information on common aquarium fish. |
|          | International Fancy Guppy Association | <a href="http://www.ifga.org">www.ifga.org</a>                                 | Association dedicated to the Fancy Show Guppy. Contains general starter information and medical information on guppies.                                         |
| Herptile | Bearded Dragon Care                   | <a href="http://www.beardeddragoncare.net">www.beardeddragoncare.net</a>       | Web site dedicated to provide bearded dragon care information to pet lizard owners.                                                                             |
|          | Boa Tips                              | <a href="http://www.boatips.com">www.boatips.com</a>                           | Web site for pet snakes. Includes husbandry and care articles as well as species-specific information and photographs.                                          |
|          | Box Turtle Care and Conservation      | <a href="http://www.boxturtlesite.info">www.boxturtlesite.info</a>             | Web site for natural history and captive care of North American box turtles.                                                                                    |
|          | Chameleon Information Network         | <a href="http://www.animalarkshelter.org/cin">www.animalarkshelter.org/cin</a> | Web site devoted to chameleons. Includes husbandry and care articles.                                                                                           |
|          | Frog World                            | <a href="http://www.frogworld.net">www.frogworld.net</a>                       | Web site concerning natural history, husbandry, and care of multiple frog species.                                                                              |

*Continued*

| Category | Site Name                             | Web Site                                                                 | Description                                                                                                                                                   |
|----------|---------------------------------------|--------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------|
|          | Global Gecko Association              | <a href="http://www.gekkota.com">www.gekkota.com</a>                     | Association dedicated to gecko enthusiasts. Contains taxonomically organized photographs and species care sheets.                                             |
|          | Green Iguana Society                  | <a href="http://www.greenigsociety.org">www.greenigsociety.org</a>       | Society dedicated to providing quality information on iguana care. Contains husbandry and care articles as well as some medical information.                  |
|          | Lizard-landscapes.com                 | <a href="http://www.lizard-landscapes.com">www.lizard-landscapes.com</a> | Web site with husbandry and care information for multiple species of reptiles. Also contains information on building cage landscapes.                         |
|          | The Lizard Lounge                     | <a href="http://www.the-lizard-lounge.com">www.the-lizard-lounge.com</a> | Web site containing husbandry and care information as well as taxonomy, photographs, natural history, and medical information on multiple species of lizards. |
|          | Melissa Kaplan's Herp Care Collection | <a href="http://www.anapsid.org">www.anapsid.org</a>                     | Web site containing husbandry and care articles on amphibians, reptiles, and invertebrates.                                                                   |
|          | Pet Snake Care                        | <a href="http://www.petsnakecare.net">www.petsnakecare.net</a>           | Web site containing husbandry and care information as well as species-specific photographs and information.                                                   |
|          | Poison Dart Frogs                     | <a href="http://www.poisondartfrog.co.uk">www.poisondartfrog.co.uk</a>   | Web site containing husbandry and care information on <i>Dendrobates</i> species.                                                                             |
|          | Reptile Web                           | <a href="http://www.reptilesweb.com">www.reptilesweb.com</a>             | A world reptile amphibian information center. Contains husbandry and care information for reptiles, amphibians, and invertebrates.                            |
|          | Snake Tracks                          | <a href="http://snaketracks.com">http://snaketracks.com</a>              | Web site for pet snakes with forums, care sheets, and species identification.                                                                                 |

| Category | Site Name                         | Web Site                                                                               | Description                                                                                                                                                |
|----------|-----------------------------------|----------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Avian    | Tortoise Trust                    | <a href="http://www.tortoisetrust.org">www.tortoisetrust.org</a>                       | Web site with information on turtles and tortoises including species care sheets and husbandry articles.                                                   |
|          | World Chelonian Trust             | <a href="http://www.chelonia.org">www.chelonia.org</a>                                 | Web site with information on turtles and tortoises including species care sheets and chelonian taxonomy.                                                   |
|          | American Budgerigar Society       | <a href="http://www.abs1.org">www.abs1.org</a>                                         | Society for information about keeping, breeding and exhibiting budgerigars.                                                                                |
|          | American Federation of Aviculture | <a href="http://www.afabirds.org">www.afabirds.org</a>                                 | Nonprofit organization whose purpose is to represent all aspects of aviculture and to educate the public about keeping and breeding birds in captivity.    |
|          | African Love Bird Society         | <a href="http://www.africanlovebirdsociety.com">www.africanlovebirdsociety.com</a>     | Association dedicated to keeping, breeding, and showing of Love Birds. Contains husbandry and care information along with information on the nine species. |
|          | American Dove Association         | <a href="http://www.doveline.com">www.doveline.com</a>                                 | Association for dove enthusiasts. Contains husbandry and care information along with information on the different species.                                 |
|          | American Ostrich Association      | <a href="http://www.ostriches.org">www.ostriches.org</a>                               | Association to establish the standards for the highest quality American Ostrich products to ensure the long-term viability of the industry.                |
|          | Foraging For Parrots              | <a href="http://foragingforparrots.com">http://foragingforparrots.com</a>              | Web site on how to make foraging toys for psittacines.                                                                                                     |
|          | International Parrotlet Society   | <a href="http://www.parrotlettranch.com/ips.html">www.parrotlettranch.com/ips.html</a> | Society to educate on the proper care, maintenance, breeding, exhibition, conservation, and preservation of all three genera of parrotlets.                |

*Continued*



| Category | Site Name                                | Web Site                                                                         | Description                                                                                                                                                                            |
|----------|------------------------------------------|----------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|          | National Cockatiel Society               | <a href="http://www.cockatiels.org">www.cockatiels.org</a>                       | Society dedicated to providing information on the proper care, handling, maintenance, and breeding of cockatiels.                                                                      |
|          | National Finch and Softbill Society      | <a href="http://www.nfss.org">www.nfss.org</a>                                   | Society dedicated to promoting the enjoyment of keeping and breeding finches and softbills.                                                                                            |
|          | North American Cockatiel Society         | <a href="http://www.cockatiel.org">www.cockatiel.org</a>                         | Society for owners of pet cockatiels. Contains information on husbandry and care of cockatiels as well as genetics and mutations.                                                      |
|          | Parrot A.L.E.R.T.                        | <a href="http://parrotalert.org">http://parrotalert.org</a>                      | Avian Love, Education, and Resource Team. Contains multiple species care sheets.                                                                                                       |
|          | Parrot Outreach Society                  | <a href="http://www.parrotoutreachsociety.org">www.parrotoutreachsociety.org</a> | Society dedicated to helping birds find homes. Includes basic bird care articles.                                                                                                      |
| Mammal   | Wings Central                            | <a href="http://www.wingscentral.org">www.wingscentral.org</a>                   | Web site sponsored by the African Parrot Society and dedicated to all parrot species. Contains husbandry and care information as well as multiple species-specific information sheets. |
|          | World Parrot Trust                       | <a href="http://www.parrots.org">www.parrots.org</a>                             | Organization to promote survival of all parrot species in the wild and to advocate for the welfare of individual birds in our homes.                                                   |
|          | American Fancy Rat and Mouse Association | <a href="http://www.afrma.org">www.afrma.org</a>                                 | Association to promote and encourage the breeding and exhibition of fancy rats and mice for show and pets.                                                                             |
|          | American Ferret Association              | <a href="http://www.ferret.org">www.ferret.org</a>                               | Association to promote the domestic ferret as a companion animal through public education via shows, newsletters, legislative education, and other venues.                             |

| Category | Site Name                            | Web Site                                                                 | Description                                                                                            |
|----------|--------------------------------------|--------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------|
|          | American Gerbil Society              | <a href="http://agsgerbils.org">http://agsgerbils.org</a>                | Society providing support and education to breeders, caregivers, and gerbil enthusiasts.               |
|          | American Rabbit Breeders Association | <a href="http://www.arba.net">www.arba.net</a>                           | Association dedicated to the promotion, development, and improvement of the domestic rabbit and cavy.  |
|          | Cheeky Chinchilla                    | <a href="http://www.cheekychinchillas.com">www.cheekychinchillas.com</a> | Husbandry and care information for chinchillas.                                                        |
|          | Ferret Central                       | <a href="http://www.ferretcentral.org">www.ferretcentral.org</a>         | Husbandry and care information for ferrets.                                                            |
|          | Ferret Universe                      | <a href="http://www.ferretuniverse.com">www.ferretuniverse.com</a>       | Husbandry and care information for ferrets.                                                            |
|          | Ferret Village                       | <a href="http://www.ferretvillage.org">www.ferretvillage.org</a>         | Message boards concerning ferrets.                                                                     |
|          | Gerbil Care                          | <a href="http://www.gerbilcare.org">www.gerbilcare.org</a>               | Husbandry and care information for gerbils.                                                            |
|          | Guinea Lynx                          | <a href="http://www.guinealynx.info">www.guinealynx.info</a>             | Husbandry and care information for guinea pigs.                                                        |
|          | Hamsterific                          | <a href="http://www.hamsterific.com">www.hamsterific.com</a>             | Husbandry and care information for hamsters.                                                           |
|          | Hamster Hideout                      | <a href="http://www.hamsterhideout.com">www.hamsterhideout.com</a>       | Husbandry and care information for hamsters.                                                           |
|          | House Rabbit Society                 | <a href="http://www.rabbit.org">www.rabbit.org</a>                       | Society that rescues rabbits from animal shelters and educates the public on rabbit care and behavior. |
|          | International Ferret Congress        | <a href="http://www.ferretcongress.org">www.ferretcongress.org</a>       | Organization to enhance the welfare of the domestic ferret as a companion animal.                      |
|          | International Hedgehog Association   | <a href="http://hedgehogclub.com">http://hedgehogclub.com</a>            | Association to educate the public in the care and betterment of hedgehogs.                             |
|          | My House Rabbit                      | <a href="http://www.myhouserabbit.com">www.myhouserabbit.com</a>         | Web site celebrating house rabbits and educating the public about rabbit care and behavior.            |

*Continued*

| Category | Site Name                               | Web Site                                                          | Description                                                                                        |
|----------|-----------------------------------------|-------------------------------------------------------------------|----------------------------------------------------------------------------------------------------|
|          | North American Sugar Glider Association | <a href="http://www.mynasga.org">www.mynasga.org</a>              | Association to provide information to persons considering getting a sugar glider for a family pet. |
|          | Pet Hamster Care                        | <a href="http://pethamstercare.com">http://pethamstercare.com</a> | Husbandry and care information for hamsters.                                                       |
|          | Rat Guide                               | <a href="http://www.ratguide.com">www.ratguide.com</a>            | A layman's guide to health, medication use, breeding, and responsible care of pet rats.            |
|          | Sugarglider                             | <a href="http://www.sugarglider.com">www.sugarglider.com</a>      | Husbandry and care information for sugar gliders.                                                  |
|          | Weasel Words                            | <a href="http://www.weaselwords.com">www.weaselwords.com</a>      | Husbandry and care information for ferrets.                                                        |

\*Web sites accessed on November 15, 2010. Please note that Elsevier Inc. and the editor of the *Exotic Animal Formulary* have not reviewed all of the content of the above sites and therefore cannot confirm the accuracy of the information presented.

TABLE A-9 Emergency Drug Doses (in mL) Commonly Used in Exotic Animals.<sup>a</sup>

| Emergency Drug   |               |            | Mice, Gerbils, Hamsters, Rats |      |      |       |       |       |       |       | Guinea Pigs, Chinchillas |      |        |
|------------------|---------------|------------|-------------------------------|------|------|-------|-------|-------|-------|-------|--------------------------|------|--------|
| Drug             | Concentration | Route      | 25 g                          | 50 g | 75 g | 100 g | 125 g | 150 g | 250 g | 500 g | 0.5 kg                   | 1 kg | 1.5 kg |
| Epinephrine      | 0.01 mg/mL    | IV, IM, IO | 0.01                          | 0.02 | 0.02 | 0.03  | 0.04  | 0.05  | 0.08  | 0.15  | 0.15                     | 0.3  | 0.45   |
| Atropine         | 0.54 mg/mL    | IM, SC     | 0.03                          | 0.04 | 0.06 | 0.07  | 0.09  | 0.11  | 0.19  | 0.37  | 0.37                     | 0.74 | 1.11   |
| Glycopyrrolate   | 0.2 mg/mL     | IM, SC     | 0.01                          | 0.01 | 0.01 | 0.01  | 0.02  | 0.02  | 0.03  | 0.05  | 0.05                     | 0.1  | 0.15   |
| Dexamethasone SP | 4 mg/mL       | IV, IM     | 0.03                          | 0.06 | 0.09 | 0.13  | 0.16  | 0.19  | 0.32  | 0.63  | 0.63                     | 1.25 | 1.87   |
| Doxapram         | 20 mg/mL      | IV, SC     | 0.02                          | 0.03 | 0.04 | 0.05  | 0.07  | 0.08  | 0.13  | 0.25  | 0.25                     | 0.5  | 0.75   |
| Diazepam         | 5 mg/mL       | IV, IM, IO | 0.01                          | 0.03 | 0.05 | 0.06  | 0.08  | 0.09  | 0.15  | 0.3   | 0.3                      | 0.6  | 0.9    |
| Furosemide       | 5 mg/mL       | IV, IM, SC | 0.02                          | 0.04 | 0.06 | 0.08  | 0.1   | 0.12  | 0.2   | 0.4   | 0.4                      | 0.8  | 0.12   |

| Emergency Drug   |               |            | Rabbits |      |        |      |      |      |      | Ferrets |      |        |      |
|------------------|---------------|------------|---------|------|--------|------|------|------|------|---------|------|--------|------|
| Drug             | Concentration | Route      | 0.5 kg  | 1 kg | 1.5 kg | 2 kg | 3 kg | 4 kg | 5 kg | 0.5 kg  | 1 kg | 1.5 kg | 2 kg |
| Epinephrine      | 1 mg/mL       | IV, IM, IO | 0.5     | 1.0  | 1.5    | 2.0  | 3.0  | 4.0  | 5.0  | 0.1     | 0.2  | 0.3    | 0.4  |
| Atropine         | 0.54 mg/mL    | IM, SC     | 0.5     | 0.9  | 1.4    | 1.9  | 2.8  | 3.7  | 4.6  | 0.05    | 0.1  | 0.15   | 0.2  |
| Glycopyrrolate   | 0.2 mg/mL     | IM, SC     | 0.05    | 0.1  | 0.15   | 0.2  | 0.3  | 0.4  | 0.5  | 0.03    | 0.05 | 0.08   | 0.1  |
| Dexamethasone SP | 4 mg/mL       | IV, IM     | 0.25    | 0.5  | 0.75   | 1.0  | 1.5  | 2.0  | 2.5  | 1.0     | 2.0  | 3.0    | 4.0  |
| Doxapram         | 20 mg/mL      | IV, SC     | 0.13    | 0.25 | 0.38   | 0.5  | 0.75 | 1.0  | 1.3  | 0.05    | 0.1  | 0.15   | 0.2  |

Continued

| Emergency Drug  |               |            | Rabbits |      |        |      |      |      |      | Ferrets |      |        |      |
|-----------------|---------------|------------|---------|------|--------|------|------|------|------|---------|------|--------|------|
| Drug            | Concentration | Route      | 0.5 kg  | 1 kg | 1.5 kg | 2 kg | 3 kg | 4 kg | 5 kg | 0.5 kg  | 1 kg | 1.5 kg | 2 kg |
| Diazepam        | 55 mg/mL      | IV, IM, IO | 0.3     | 0.6  | 0.9    | 1.2  | 1.8  | 2.4  | 3.0  | 0.2     | 0.4  | 0.6    | 0.8  |
| Furosemide      | 50 mg/mL      | IV, IM, SC | 0.04    | 0.08 | 0.12   | 0.16 | 0.24 | 0.32 | 0.4  | 0.04    | 0.08 | 0.12   | 0.16 |
| Diphenhydramine | 50 mg/mL      | IV, IM     | —       | —    | —      | —    | —    | —    | —    | 0.02    | 0.04 | 0.06   | 0.08 |

| Emergency Drug |               |            | Avian (Psittacines) |        |        |        |        |        |        |        |        |        |        |
|----------------|---------------|------------|---------------------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|
| Drug           | Concentration | Route      | 0.05 kg             | 0.1 kg | 0.2 kg | 0.3 kg | 0.4 kg | 0.5 kg | 0.6 kg | 0.7 kg | 0.8 kg | 0.9 kg | 1.0 kg |
| Epinephrine    | 1 mg/mL       | IV, IM, IO | 0.05                | 0.1    | 0.2    | 0.3    | 0.4    | 0.5    | 0.6    | 0.7    | 0.8    | 0.9    | 1.0    |
| Atropine       | 0.54 mg/mL    | IM, SC     | 0.05                | 0.09   | 0.19   | 0.28   | 0.37   | 0.46   | 0.56   | 0.65   | 0.74   | 0.83   | 0.93   |
| Doxapram       | 20 mg/mL      | IV, IM, IO | 0.05                | 0.1    | 0.2    | 0.3    | 0.4    | 0.5    | 0.6    | 0.7    | 0.8    | 0.9    | 1.0    |
| Dex SP         | 4 mg/mL       | IV, IM     | 0.05                | 0.1    | 0.2    | 0.3    | 0.4    | 0.5    | 0.6    | 0.7    | 0.8    | 0.9    | 1.0    |
| Ca gluconate   | 100 mg/mL     | IV, IM     | 0.05                | 0.1    | 0.2    | 0.3    | 0.4    | 0.5    | 0.6    | 0.7    | 0.8    | 0.9    | 1.0    |
| Diazepam       | 5 mg/mL       | IV, IM, IO | 0.01                | 0.02   | 0.04   | 0.06   | 0.08   | 0.1    | 0.12   | 0.14   | 0.16   | 0.18   | 0.2    |

| Emergency Drug |               |             | Reptiles |         |        |         |      |      |      |      |      |      |      |
|----------------|---------------|-------------|----------|---------|--------|---------|------|------|------|------|------|------|------|
| Drug           | Concentration | Route       | 0.1 kg   | 0.25 kg | 0.5 kg | 0.75 kg | 1 kg | 2 kg | 3 kg | 4 kg | 5 kg | 6 kg | 7 kg |
| Atropine       | 0.54 mg/mL    | IV, IM, SC  | 0.01     | 0.02    | 0.04   | 0.06    | 0.07 | 0.15 | 0.22 | 0.3  | 0.37 | 0.44 | 0.52 |
| Glycopyrrolate | 0.2 mg/mL     | IV, IM      | 0.01     | 0.02    | 0.03   | 0.04    | 0.05 | 0.1  | 0.15 | 0.2  | 0.25 | 0.3  | 0.35 |
| Dex SP         | 4 mg/mL       | IV, IM      | 0.01     | 0.02    | 0.03   | 0.05    | 0.06 | 0.13 | 0.19 | 0.25 | 0.31 | 0.38 | 0.44 |
| Diazepam       | 5 mg/mL       | IV, IM, ICe | 0.05     | 0.12    | 0.25   | 0.38    | 0.5  | 1.0  | 1.5  | 2.0  | 2.5  | 3.0  | 3.5  |
| Ca gluconate   | 100 mg/mL     | IV, IO, SC  | 0.1      | 0.3     | 0.5    | 0.75    | 1.0  | 2.0  | 3.0  | 4.0  | 5.0  | 6.0  | 7.0  |

\*Modified from Kottwitz J, Kallisher S. Emergency drugs: Quick reference chart for exotic animals. *Exotic DVM* 2003;5:23-25.

TABLE A-10 Fluid Solutions Used in Exotic Animal Medicine.

| Solution Type | Solution                     | Na <sup>+</sup> (mEq/L) | K <sup>+</sup> (mEq/L) | Cl <sup>-</sup> (mEq/L) | Ca <sup>++</sup> (mEq/L) | Mg <sup>++</sup> (mEq/L) | Buffer (mEq/L)                  | Osmolality (mOsm/L) | pH    |
|---------------|------------------------------|-------------------------|------------------------|-------------------------|--------------------------|--------------------------|---------------------------------|---------------------|-------|
| Crystalloids  | Ringer's solution            | 147                     | 4                      | 156                     | 4                        | 0                        | 0                               | 310                 | 5-7.5 |
|               | Lactated Ringer's solution   | 130                     | 4                      | 109                     | 3                        | 0                        | 28 (lactate)                    | 275                 | 6-7.5 |
|               | 0.9% NaCl                    | 154                     | 0                      | 154                     | 0                        | 0                        | 0                               | 308                 | 4.5   |
|               | 5% Dextrose                  | 0                       | 0                      | 0                       | 0                        | 0                        | 0                               | 252                 | 4-6.5 |
|               | 2.5% Dextrose/<br>0.45% NaCl | 77                      | 0                      | 77                      | 0                        | 0                        | 0                               | 280                 | 4.5   |
|               | Plasma-Lyte                  | 140                     | 5                      | 98                      | 0                        | 3                        | 27 (acetate),<br>23 (gluconate) | 294                 | 4-6.5 |
|               | Normosol-R                   | 140                     | 5                      | 98                      | 0                        | 3                        | 27 (acetate),<br>23 (gluconate) | 294                 | 6.6   |
| Colloids      | Dextran 6% and 0.9% NaCl     | 154                     | 0                      | 154                     | 0                        | 0                        | 0                               | 310                 | 3-7.0 |
|               | Helastarch                   | 154                     | 0                      | 154                     | 0                        | 0                        | 0                               | 309                 | 5.5   |
|               | Pentastarch                  | 154                     | 0                      | 154                     | 0                        | 0                        | 0                               | 326                 | 5.0   |
|               | Hemoglobin glutamer          | —                       | —                      | —                       | —                        | —                        | —                               | 300                 | 7.8   |

TABLE A-11 Common Abbreviations Used in Prescription Writing.

|        |                   |              |                         |
|--------|-------------------|--------------|-------------------------|
| a.c.   | before meals      | o.d.         | right eye               |
| a.d.   | right ear         | o.s.         | left eye                |
| ad lib | at pleasure       | o.u.         | both eyes               |
| adm    | administer        | oz           | ounce                   |
| aq     | water             | p.c.         | after meals             |
| a.s.   | left ear          | PO (p.o.)    | per os                  |
| a.u.   | both ears         | prn (p.r.n.) | as needed               |
| b.i.d. | twice a day       | q. (q)       | every                   |
| c.     | with              | q.d.         | every day               |
| cap(s) | capsule(s)        | q4h          | every 4 hours, etc.     |
| cc     | cubic centimeter  | q24h         | once a day              |
| disp   | dispense          | q.i.d.       | four times a day        |
| fl oz  | fluid ounce       | q.o.d.       | every other day         |
| g (gm) | gram              | q.s.         | a sufficient quantity   |
| gr     | grain             | ®            | trademarked name        |
| gtt(s) | drop(s)           | SC (SQ)      | subcutaneously          |
| h (hr) | hour              | Sig:         | instructions to patient |
| h.s.   | at bedtime        | sol'n        | solution                |
| IM     | intramuscularly   | stat         | immediately             |
| inj    | inject            | susp         | suspension              |
| IP     | intraperitoneally | tab(s)       | tablet(s)               |
| IV     | intravenously     | Tbs          | tablespoon              |
| kg     | kilogram          | t.i.d.       | three times a day       |
| lb     | pound             | tsp          | teaspoon                |
| mg     | milligram         | ut dict.     | as directed             |
| mL     | milliliter        |              |                         |

TABLE A-12 Common Weight, Liquid Measure, Length, Percentage, and Milliequivalent Conversions.

| Weights                                                      |
|--------------------------------------------------------------|
| 1 milligram (mg) = 1000 micrograms (mcg or µg) = 0.015 grain |
| 1 grain (gr) = 64.8 mg (≈65 mg)                              |
| 1 gram (g) = 15.43 grains (≈15 grains) = 1000 mg             |
| 1 kilogram (kg) = 1000 g = 2.2 lb                            |
| 1 ounce (oz) = 28.35 g                                       |

1 pound (lb) = 454 g = 16 oz = 0.45 kg

2.2 pound = 1 kg

**Liquid Measures**

1 drop = 0.05 (1/20) milliliter (mL)

1 cubic centimeter (cc) = 1 mL

1 liter (L) = 1000 mL

1 teaspoon (tsp) = 5 mL

1 tablespoon (Tbs) = 15 mL

1 fluid ounce (fl oz) = 29.57 mL ( $\approx$ 30 mL)

1 pint = 473.2 mL ( $\approx$ 473 mL)

1 quart = 2 pints = 32 fl oz = 0.946 L)

1 gallon = 4 quarts = 3.785 L

1 cup = 8 fl oz = 237 mL = 16 Tbs

**Linear Measures**

1 millimeter (mm) = 0.039 inches (in)

1 centimeter (cm) = 0.39 in

1 meter (m) = 39.37 in

1 inch (in) = 2.54 cm

1 foot (ft) = 30.48 cm

1 yard (yd) = 91.44 cm

**Percentage Equivalents**

0.1% solution = 1 mg per mL

1% solution = 10 mg per mL

10% solution = 100 mg per mL

**Milliequivalents**

- 1 mEq Na = 23 mg Na = 58.5 mg NaCl
- 1 g Na = 2.54 g Na Cl = 43 mEq Na
- 1 g NaCl = 0.39 g Na = 17 mEq Na
- 1 mEq K = 39 mg K = 74.5 mg KCl
- 1 g K = 1.91 g KCl = 26 mEq K
- 1 g KCl = 0.52 g K = 13 mEq K
- 1 mEq Ca = 20 mg Ca
- 1 g Ca = 50 mEq Ca
- 1 mEq Mg = 0.12 g MgSO<sub>4</sub> . 7H<sub>2</sub>O
- 1 g Mg = 10.2 g MgSO<sub>4</sub> . 7H<sub>2</sub>O = 82 mEq Mg

TABLE A-13 Equivalents of Celsius (Centigrade) and Fahrenheit Temperature Scales.<sup>a</sup>



| °C | °F   | °C | °F   | °C | °F    |
|----|------|----|------|----|-------|
| 0  | 32.0 | 17 | 62.6 | 34 | 93.2  |
| 1  | 33.8 | 18 | 64.4 | 35 | 95.0  |
| 2  | 35.6 | 19 | 66.2 | 36 | 96.8  |
| 3  | 37.4 | 20 | 68.0 | 37 | 98.6  |
| 4  | 39.2 | 21 | 69.8 | 38 | 100.4 |
| 5  | 41.0 | 22 | 71.6 | 39 | 102.2 |
| 6  | 42.8 | 23 | 73.4 | 40 | 104.0 |
| 7  | 44.6 | 24 | 75.2 | 41 | 105.8 |
| 8  | 46.4 | 25 | 77.0 | 42 | 107.6 |
| 9  | 48.2 | 26 | 78.8 | 43 | 109.4 |
| 10 | 50.0 | 27 | 80.6 | 44 | 111.2 |
| 11 | 51.8 | 28 | 82.4 | 45 | 113.0 |
| 12 | 53.6 | 29 | 84.2 | 46 | 114.8 |
| 13 | 55.4 | 30 | 86.0 | 47 | 116.6 |
| 14 | 57.2 | 31 | 87.8 | 48 | 118.4 |
| 15 | 59.0 | 32 | 89.6 | 49 | 120.2 |
| 16 | 60.8 | 33 | 91.4 | 50 | 122.0 |

<sup>a</sup>Conversions: °C = 5/9 × (°F -32); °F = 9/5 × (°C) + 32

TABLE A-14 System of International (SI) Units Conversion Factors of Clinical Chemistries Commonly Used in Exotic Animal Medicine.<sup>a</sup>

| Component                   | Conventional (USA)<br>Units | Conversion Factor (x) | SI Unit |
|-----------------------------|-----------------------------|-----------------------|---------|
| Albumin                     | g/dL                        | 10                    | g/L     |
| Alkaline phosphatase        | U/L                         | 1.0                   | IU/L    |
| ALT (SGPT)                  | U/L                         | 1.0                   | IU/L    |
| Ammonia (NH <sub>4</sub> )  | μg/dL                       | 0.5871                | μmol/L  |
| Amylase                     | U/L                         | 1.0                   | IU/L    |
| AST (SGOT)                  | U/L                         | 1.0                   | IU/L    |
| Bilirubin                   | mg/dL                       | 17.10                 | μmol/L  |
| Calcium                     | mg/dL                       | 0.2495                | mmol/L  |
| Carbon dioxide              | mEq/L                       | 1.0                   | mmol/L  |
| Chloride                    | mEq/L                       | 1.0                   | mmol/L  |
| Cholesterol                 | mg/dL                       | 0.02586               | mmol/L  |
| Copper                      | μg/dL                       | 0.16                  | μmol/L  |
| Cortisol                    | μg/dL                       | 27.59                 | nmol/L  |
| Creatine kinase             | U/L                         | 1.0                   | IU/L    |
| Creatinine                  | mg/dL                       | 88.40                 | μmol/L  |
| Fibrinogen                  | mg/dL                       | 0.01                  | g/L     |
| Glucose                     | mg/dL                       | 0.05551               | mmol/L  |
| Iron                        | μg/dL                       | 0.1791                | μmol/L  |
| Lipase                      |                             |                       |         |
| Sigma Tietz                 | U/dL                        | 280                   | IU/L    |
| Cherry-Crandall             | U/L                         | 1.0                   | IU/L    |
| Lipid, total                | mg/dL                       | 0.01                  | g/L     |
| Magnesium                   | mEq/L                       | 0.5                   | mmol/L  |
| Osmolality                  | mOsm/kg                     | 1.0                   | mmol/kg |
| Phosphate (as inorganic P)  | mg/dL                       | 0.3229                | mmol/L  |
| Potassium                   | mEq/L                       | 1.0                   | mmol/L  |
| Protein (total)             | g/dL                        | 10                    | g/L     |
| Sodium                      | mEq/L                       | 1.0                   | mmol/L  |
| Thyroxine (T <sub>4</sub> ) | μg/dL                       | 12.87                 | nmol/L  |

| Component                           | Conventional (USA)<br>Units | Conversion Factor (x) | SI Unit             |
|-------------------------------------|-----------------------------|-----------------------|---------------------|
| Triglycerides                       | mg/dL                       | 0.011                 | mmol/L              |
| Tri-iodothyronine (T <sub>3</sub> ) | μg/dL                       | 15.6                  | nmol/L              |
| Urea nitrogen                       | mg/dL                       | 0.3570                | mmol/L <sup>b</sup> |
| Uric acid                           | mg/dL                       | 0.059                 | mmol/L              |

<sup>a</sup>Adapted from *Veterinary Laboratory Medicine: Interpretation and Diagnosis*, Meyer D.H., Harvey J.W., 3<sup>rd</sup> ed., Copyright, 2004, with permission from Elsevier.  
<sup>b</sup>Urea.

TABLE A-15 System of International (SI) Units Conversion Factors of Hematology Commonly Used in Exotic Animal Medicine.<sup>a</sup>

| Component                                 | Conventional (USA)<br>Units | Conversion<br>Factor (x) | SI Unit                |
|-------------------------------------------|-----------------------------|--------------------------|------------------------|
| Hemoglobin (Hgb)                          | g/dL                        | 0.1                      | g/L                    |
| Red blood cells (RBC)                     | × 10 <sup>6</sup> /μL       | —                        | × 10 <sup>12</sup> g/L |
| Reticulocytes                             | %                           | —                        | %                      |
| Mean corpuscular volume (MCV)             | fL                          | —                        | fL                     |
| Mean corpuscular Hgb (MCH)                | pg                          | —                        | pg                     |
| Mean corpuscular Hgb concentration (MCHC) | g/dL                        | 0.1                      | g/L                    |
| Platelets                                 | × 10 <sup>3</sup> /μL       | —                        | × 10 <sup>9</sup> /L   |
| White blood cells (WBC)                   | × 10 <sup>3</sup> /μL       | —                        | × 10 <sup>9</sup> /L   |
| Neutrophils (segmented)                   | × 10 <sup>3</sup> /μL       | —                        | × 10 <sup>9</sup> /L   |
| Neutrophils (bands)                       | × 10 <sup>3</sup> /μL       | —                        | × 10 <sup>9</sup> /L   |
| Lymphocytes                               | × 10 <sup>3</sup> /μL       | —                        | × 10 <sup>9</sup> /L   |
| Monocytes                                 | × 10 <sup>3</sup> /μL       | —                        | × 10 <sup>9</sup> /L   |
| Eosinophils                               | × 10 <sup>3</sup> /μL       | —                        | × 10 <sup>9</sup> /L   |
| Basophils                                 | × 10 <sup>3</sup> /μL       | —                        | × 10 <sup>9</sup> /L   |

<sup>a</sup>Adapted from *Veterinary Laboratory Medicine: Interpretation and Diagnosis*, Meyer D.H., Harvey J.W., 3<sup>rd</sup> ed., Copyright, 2004, with permission from Elsevier.



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