RECENT CROCODILE ATTACKS IN AUSTRALIA

Oběti boha Sobka

Útoky krokodýlů a aligátorů na člověka

ZDEŇKA SŮVOVÁ

Krokodýl je protagonistou mnoha mytologií. V Austrálii je uctíván jako totemové zvíře, ve starém Egyptě byl jako bůh Sobek odpovědný za déšť a záplavy. V některých kmenech je zakázáno ho zabít (například u Ibanů na Borneu), jinde lidé alespoň věří, že jeho zabití přináší neštěstí (v některých končinách Kambodže). V Indii bývali posvátní krokodýlové zdobeni šperky a krmeni rituálními obětinami, na Madagaskaru zas prostřednictvím „krokodýlího" soudu určovali viníka. I dnes jsou krokodýlové uctíváni a chráněni podobně jako jiné vymírající druhy. V tomto případě se však snaha chránit je často setkává s nenávistí kvůli tomu, že člověk – alespoň pro většího krokodýla – představuje kořist vhodné velikosti.

Systematické záznamy nemáme

S výjimkou aligátora severoamerického v USA a krokodýla mořského v Austrálii nejsou o útocích krokodýlů vedeny systematické záznamy. V celkovém obrazu pak nastává podobné zkreslení jako u žraločích útoků, kde se na základě záznamů paradoxně zdá, že žraloci útočí přednostně na anglofonní obyvatele.[1] Přitom je zřejmé, že se krokodýli v mnoha afrických a asijských oblastech vyskytují v nepoměrně větším množství než v USA a Austrálii. Údaje o útocích totiž začínají být shromažďovány až v okamžiku, kdy se krokodýl stane v dané oblasti chráněným, a tudíž je třeba sledovat jeho činnost.

Napadeno bývá víc lidí, než je hlášeno

Množství útoků krokodýlů na lidi mnohonásobně převyšuje počet žraločích útoků, což je dáno hlavně tím, že se životní prostor lidí častěji překrývá s životním prostorem krokodýla než s životním prostorem žraloka. Kvantifikovat tyto útoky je obtížné, s určitostí lze prohlásit, že napadeno bývá mnohem více lidí, než je hlášeno. Seriózní odhady se pohybují kolem několika tisíc obětí krokodýlích útoků za rok. Liší se především v míře zavinění krokodýla mořského a krokodýla nilského, což patrně souvisí s národností autora té které studie.

V některých oblastech mohou být krokodýlí útoky nezvykle časté a leckde lze najít historické souvislosti – například ve vesnici Sešeke na řece Zambezi kdysi krokodýlům házeli vězně. Tento zvyk byl zrušen r. 1870, ale ještě desetiletí poté v těchto končinách krokodýli napadali lidi mnohem častěji než jinde. Na člověka příležitostně útočí největší druhy krokodýlů, zejména krokodýl mořský a krokodýl nilský, dále krokodýl orinocký, krokodýl americký, krokodýl bahenní, aligátor severoamerický a kajman černý (to je 7 druhů ze současných asi 24). Lidské pozůstatky byly nalezeny i v útrobách gaviála, u něj se však předpokládá, že požírá mrtvoly plovoucí po posvátné řece Ganze (navíc má dlouhé a úzké čelisti, které ho předurčují jako specialistu na lov ryb).

Některým jedincům je přičítáno až přes 400 obětí, tyto údaje jsou však zřejmě přehnané. Doloženo bylo zatím nanejvýš 13 obětí, a to u krokodýla mořského z malajského Sarawaku, který byl dlouhý 5,8 metru. Často připomínán je pak smutně proslulý ústup 800–1000 japonských vojáků v noci 19. února 1942 do mangrovových porostů na pobřeží Barmy (do zátoky u ostrova Ramree) – podle svědků bylo druhý den ráno zachráněno sotva 20 vojáků; polovina obětí se připisuje krokodýlům (druhá polovina střelbě). Tato událost však byla několikrát zpochybněna, otázkou zůstává, zda by i velká populace krokodýlů v této oblasti dokázala způsobit takové ztráty. Oficiálně zůstává nejvyšším počtem krokodýlích obětí během jedné akce 40 cestujících lodi, která se potopila v prosinci 1975 na řece Malili na ostrově Celebes.

Krokodýli v Austrálii

V Austrálii bylo vyhodnoceno 62 dokončených nevyprovokovaných útoků krokodýla mořského končících úrazem nebo smrtí z let 1971–2004. Celkem 17 útoků (27 %) bylo smrtelných – všechny tyto útoky byly vedeny na lidi ve vodě (plavali nebo se brodili); 10 z těchto útoků se odehrálo při špatném světle nebo v noci; u 8 lidí byl zjištěn alkohol (střízlivý člověk si asi těžko půjde v noci

1) Většina útoků byla zaznamenána v Austrálii, ve Spojených státech a v Jihoafrické republice.

← **Na Madagaskaru žije národ Antankaranů (Vesmír 81, 434, 2002/8). Podle legendy se jejich předci proměnili v krokodýly a žijí v jezeře Antanavo. Vážené antankaranské rodiny dodnes odvozují svůj původ až k oněm legendárním krokodýlům. Lidé plazím „předkům" přinášejí k jezeru obětiny. Dnes jsou to kusy hovězího, ale v minulosti to bývali i lidé, obvykle mladé dívky. V posledních několika desetiletích se ovšem rituál proměnil spíš na představení pro turisty.**
Na horním snímku krokodýl nilský (*Crocodilus niloticus*) u posvátného jezera Antanavo nedaleko vesnice Anivorano na severu Madagaskaru, dole jedinec ze soukromé rezervace Vakona, kousek na sever od městečka Andasibe. Snímky © Jiří Bálek.

Mgr. Zdeňka Sůvová (*1978) vystudovala zoologii na Jihočeské univerzitě v Českých Budějovicích, v doktorském studiu tamtéž se zabývá paleoekologií. Na Západočeské univerzitě a v Západočeském institutu pro ochranu a dokumentaci památek v Plzni pracuje v oboru archeozoologie.

Bůh Sobek v podobě muže s krokodýlí hlavou. Travertinová dyáda Amenhotepa III. pochází původně ze Sobkova chrámu v Damanše. Muzeum v Luxoru. Snímek © Milan Zemina.

zaplavat do míst, kde je břeh poset cedulemi s varováním, zvláště ústí-li v daném místě odpad z masokombinátu, jak to učinil např. jeden mladík). U smrtelných útoků byla zaznamenána průměrná délka krokodýla 4,3 metru (takže šlo většinou o samce), u ostatních útoků byla průměrná délka útočníka 3 metry – tento rozdíl není zarážející za předpokladu, že větší velikost krokodýla znamená menší šanci přežití napadeného. Rozborem všech útoků (smrtelných i ostatních) se ukázalo, že 75 % obětí byli muži a průměrný věk obětí byl 31 let (29 ze 48 známých údajů tvořila věková kategorie 20–40 let). Důvody útoků na lidi byly seřazeny v následujícím pořadí: obrana teritoria, obrana hnízda a mláďat, potravní důvody, omyl (krokodýl nešel po lidech, ale po psovi) a sebeobrana. Kromě fatálních útoků byly zaznamenány i útoky na čluny (obrana teritoria proti jinému velkému krokodýlovi) nebo útoky na lidi na souši, včetně dvou případů, kdy krokodýl napadl spící lidi ve stanu.

Aligátoři na Floridě

Podobný výzkum probíhá také na jihu USA, zejména na Floridě. V příspěvku bylo shrnuto 376 veškerých známých útoků z let 1948–2005. Zaznamenáno zde za tu dobu bylo 25 obětí, u 9 z nich se ovšem předpokládá, že byly mrtvé ještě předtím, než se staly potravou aligátorů. Většina útoků se uskutečnila v červnu až v srpnu. U útoků lze vysledovat zjevnou tendenci k nárůstu jejich frekvence od konce osmdesátých let, což může souviset jak s rostoucí populací aligátorů, tak s rostoucí populací člověka v dané oblasti, popřípadě i s podrobnějším zaznamenáváním bezvýznamnějších událostí z posledních desetiletí. Unikátní je v této zprávě výčet činností, které oběti prováděly v době, kdy na ně byl veden útok; mezi 4 nejčastější náleží (v tomto pořadí!): pokus chytit nebo předvést aligátora, plavání, rybaření a sběr golfových míčků (vše 10 % útoků a více); nalezneme zde i další činnosti, jako je brodění, šnorchlování, venčení psa, ale i zahradničení na břehu nebo šlápnutí na aligátora a mnohé další. Až do r. 1973, kdy zemřela šestnáctiletá dívka, se tvrdilo, že aligátor není schopen zabít člověka.[2] Aligátor je totiž mnohem mírnější povahy než jeho příbuzní z čeledi krokodýlovitých, což dosvědčí všichni chovatelé, kteří mají zkušenosti s oběma skupinami těchto plazů. Od té doby do r. 2005 bylo zaznamenáno dalších 15 smrtelných útoků, průměrná délka útočícího zvířete byla 3,1 m.[3] Na rozdíl od předchozí zprávy se ve věkové kategorii 20–40 let nacházela jediná oběť, naopak ve věku do 20 let bylo 9 z oněch 16 obětí, mezi zbylými 6 oběťmi pak byli spíše staří lidé.[4] Z popisu jednotlivých útoků vyplývá, že aligátoři útočili na malé děti (do 5 let) a staré lidi na břehu, kdežto všechny starší děti a dospívající dívky (10–20 let) se nacházely v době útoku ve vodě. Z toho by plynulo, že většina útoků byla vedena z potravních důvodů na jedince velikostně odpovídající potenciální kořisti aligátora.

Na výzkum dalších oblastí se teprve čeká

Co se týče krokodýlích útoků, jejich další výzkum by měl probíhat i v jiných oblastech, než jsou obě zmíněné. Vždyť oproti 17 obětem za 33 let v Austrálii a 16 obětem za 57 let v USA bylo zaznamenáno např. 23 zabitých krokodýly (a 12 zraněných) v Namibii od ledna 2000 do března 2004 (tedy za 4 roky) nebo 40 zabitých (a 8 zraněných) v Zambii od ledna 2002 do dubna 2004 (za dva roky!).

2) V rozporu s mýty původních obyvatel, kteří měli před aligátory potřebný respekt.

3) Šlo tedy o útočníky výrazně menší než v případě australského krokodýla mořského (4,3 m), což ovšem zřejmě souvisí i s velikostním složením obětí aligátora.

4) Je ovšem třeba říci, že v australské studii byly zahrnuty všechny útoky, kdežto ve floridském výzkumu jde pouze o útoky fatálního významu.

K dalšímu čtení

Caldicott D. G. E., Croser D., Manolis C., Webb G., Britton A.: Crocodile Attack in Australia: An Analysis of Its Incidence and Review of the Pathology and Management of Crocodilian Attacks in General, Wilderness and Environmental Medicine 16, 143–159, 2005

Langley R. L.: Alligator Attacks on Humans in the United States, Wilderness and Environmental Medicine 16, 119–124, 2005

Recent Crocodile Attacks in Australia

2002: a 23 year old German tourist is taken in Kakadu National Park when swimming in a billabong at night time. **Don't swim in still and deep waters, don't swim in unknown waters, be particularly careful at night time**. The waterhole was known to be crocodile infested...

2003: a 22 year old Northern Territory man is taken after wading too far into the Finniss River near Darwin. He and his friends knew very well about the risk of crocodile attacks. **Stay away from the water's edge**!

2005: 3 fatal crocodile attacks occurred in 2005. A man is grabbed by his arm and pulled from his canoe in northern Queensland. Apparently he had been strongly advised against canoeing... The other two crocodile attacks occurred within a week of each other, both in the ocean waters of the Northern Territory coast. In both cases the victims were diving/snorkelling.

There have been another dozen or so crocodile attacks in the same period that didn't end fatally. In all cases the lucky survivors had either been in the water, or camping far too close to the water. 50m distance is the absolute minimum, the further the better!

It also needs to be said that for an Australian saltwater crocodile to leave the water and walk into a human camp it has to be familiar with humans! You can help to **prevent attacks from happening** by not feeding crocodiles, and not discarding scraps and fish guts etc. into the water.

Update July 2006: And it doesn't stop. An eight year old girl is taken at the Blythe River in the Northern Territory. (The Blythe River is about 400 km east of Darwin, deep inside Arnhem Land. This is not an area that is accessible to tourists.)

The river has an estimated population of four to five saltwater crocodiles per kilometre. The girl had gone to the river's edge by herself, apparently to collect water. At night time!! Kids are much more likely to be victim of a crocodile attack because of their size, squatting down will make anyone look even smaller to a crocodile. A perfect target.

The "experts" called this crocodile attack "incredibly bad luck", and several Australian crocodiles were killed until the "guilty" one was found.

September 2008: A 62 year old man disappears from the banks of the Endeavor River (far northern

Queensland). He'd been camping there and checking his crab pots. Left behind were the broken rope from the pot, a video camera on the ground and a big crocodile slide mark.

Within the next two weeks three large crocodiles are caught in the area. One of them contains the remains of a human body.

February 2009: A five year old boy is taken by a large saltwater crocodile in the Daintree River (far north Queensland), in front of his brother.

March 2009: An eleven year old girl is taken by a large saltwater crocodile while swimming at Black Jungle Billabong near Darwin, in front of her friends. (The Black Jungle Reserve is accessible strictly by permit only. This is not a public swimming area or in any way monitored.) Her remains are found later on the river bank.

For those you of you who are travelling or living in crocodile infested areas, these recent statistics show how important it is to be wary at all times and to always take notice of warning signs.

Oct 2004 - NT. Teenager escapes from jaws of crocodile with only minor puncture wounds.
Oct 2004 - Qld. A four metre crocodile attacks a man sleeping in a tent on a beach at Cape Melville in far north Queensland.
Oct 2004 - Qld. A Barramundi fisherman loses the tip of his index finger, bitten off by a crocodile while he was trying to free it from a net on the Nassau River on Cape York Peninsula.
April 2004 - Qld. An 11-year-old girl has her arm grabbed by a crocodile while swimming at Margaret Bay on Cape York Peninsula.
Dec 2003 - NT. Brett Mann, 22, killed after wading into the Finniss River, 80km from Darwin.
Nov 2003 - NT. A woman beats off a crocodile with a bag of mussels after it bit her on the back while she was wading across a creek on Melville Island.
Nov 2003 - NT. Teenager Manuel Gandigorrtij escapes from the jaws of a three-metre crocodile when his 53-year-old aunt punched it in the nose at Jibalbal Outstation, in Arnhem Land.
Sept 2003 - NT. A tour guide suffers puncture wounds after being attacked by a 1.5m freshwater crocodile at a popular plunge pool in Kakadu National Park.
Sept 2003 - NT. A 10-year-old girl received cuts to her leg after being attacked by a 2.13m crocodile as she swam with friends in a billabong at the Aboriginal community at Patonga Airstrip in Kakadu National Park.
Oct 2002 - NT. German tourist Isabel von Jordan, 23, killed while swimming at a water hole at Kakadu National Park.-AAP

When food is within reach a saltwater crocodile attacks at an astonishing speed, the crocodile is capable of leaping its full body length out of the water vertically. When a crocodile has killed its prey and can't swallow it in one piece it will tear its victim to pieces by violently shaking it from side to side. The body of the victim is held above the waters surface and torn to pieces. When the victim is of a large size, the arms, legs and even the head are separated from the torso.

After the crocodile has managed this it will eat the pieces. Searchers looking for a crocodile victim will often find parts of the victims body and clothes, sometimes even in

surrounding trees.

Crocodiles will eat carrion, although popular evidence seems to show they prefer recently killed prey. Folk tales say that a crocodile will store the body of its victim until it starts to rot but there is little evidence of this. Not all crocodile attacks are born of a need to eat, sometimes they happen by accident when the creature is run into or surprised out of the water.

Crocodiles injure people under several sets of circumstances:

- **Territorial defense**
- **Nest defense**
- **Self defense**
- **Predation**
- **By accident**
- **In the course of handling by people**

Recorded Crocodile Attacks
It is hard to find material on this subject. While living in Darwin for 11 years I recall three crocodile attacks two of which were fatal and one where the lady survived with massive injuries. I will now relate those three stories as I read in the paper and was told by locals of the area. I hope I have my facts right this is all from memory.

Kakadu
A woman was paddling a canoe down a waterway by herself (how she managed to do that without someone warning her is beyond me). Her canoe hit what she thought was a floating log. It turned out to be a large crocodile which then attacked and overturned the canoe.

The woman managed to swim to the muddy sides of the waterway and clawed her way up the steep bank only to be grabbed by the leg by the crocodile and dragged back into the water and put into a death roll.

For some reason the crocodile released the woman who , severely mauled made it back to the bank and again clawed her way up to the top. She was again seized by the crocodile by the other leg but this time she had hold of part of a tree (a root or something). The crocodile mauled her again trying to pull her back into the water and again let go of her.

Severley injured the woman managed to crawl onto safe land and then through the bush where she was found and transported to hospital.

I knew two nursing staff at Darwin hospital at the time and the description of the womans injuries were horrific. She managed to keep her legs and after recovering stated that she did not want the crocodile harmed.

That crocodile reacted out of instinct, the truth of the matter is that the woman should not have been on the water in that area.

East Alligator Crossing Kakadu
A local man was fishing on the concrete barrage that vehicles use to cross the East Alligator River. A large black crocodile was known to frequent the area.

The man slipped and fell into the water in front of many witnesses. As he tried to swim to safety the crocodile swam up, took him by the head and swam away with his body in front of other people. His body was later recovered but the capture of the crocodile was prevented by local aborigines who regarded the crocodile as a totem and therefore sacred to them.

Boroloola Northern Territory
A man apparently fell asleep on the boat ramp on the river at Boroloola. He was taken by a large saltwater crocodile and his body recovered from the stomach of the crocodile when the crocodile was caught and killed.

Western Australia
A yacht entered a river system known as a habitat for large crocodiles. The yacht moored near a beautiful large waterfall that emptied into a saltwater river. An Canadian woman, dove into the water to swim to the waterfall and was attacked by a large crocodile.

Horrified, her friends watched helplessly as the crocodile swam away with their friend held above the water still alive. Her body was later recovered in the mangroves.

Again the woman entered the water. It is probably safe to assume that as she was from another country that she was unaware of the danger.

Other Attacks

Port Douglas Queensland 5 October 2001
An Australian girl has survived an attack by a salt water crocodile in Queensland. Taleesha Fagatilli was playing in the water when the six foot crocodile snapped her, dragging her into deeper water where it began a death roll. For some reason the croc then released eight-year-old Taleesha, who swam to safety. Screaming and bleeding, she managed to stagger back to her father who immediately rushed her to hospital where she had emergency surgery for deep bites and cuts to her chest, leg and arm. Her father, Bruno, said that the attack was completely unexpected in the shallow waters at Four Mile Beach, Port Douglas, in Queensland. Salt water crocodiles are the largest species of reptile and have been known to have killed twelve people in Australia over the past twenty years.

Weipa in the Gulf of Carpentaria Queensland
The 32-years old Peter Reimers, who was killed by a crocodile at Weipa in North-Queens land seems to be the victim of a characteristic encounter.

The police have investigated the shallow creek where he went to, where he undressed himself and finally bathed in to cool off. Close to the bank tracks were found of a large crocodile that was lying there and probably slid into the water silently as soon as it heard the man approaching. As soon as Reimers waded through the water he was seized and killed by the crocodile. If he was a hog or a wallaby the same thing would have happened to him.

Pindi Pindi Queensland 1933
A crocodile was responsible for killing 2 schoolgirls at Pindi Pindi, Queensland (Australia) in 1933. They disappeared after going to school on horseback - One girl was drowned, the body of the other girl was found in the crocodile's stomach. The crocodile was found and killed.

Crocodile Handler Killed 1994
A group of tourists watched in horror as a large crocodile killed his handler in a `death roll' at the Johnston River Crocodile Farm yesterday. The handler, who had two years experience with crocodiles, was inside the crocodiles enclosure. While tourists looked on, he tapped the crocodile with a rake. The 4.1m crocodile grabbed the handler by the upper arm and dragged him into the water. The crocodile rolled, taking the man's head and upper arm into its jaws. The man would have died instantly. One horrified tourist grabbed a pole and hit at the crocodile. Another grabbed hold of the victim's ankle and tried to pull him away. He said the crocodile was "just like a D7 bulldozer".
from Townsville Bulletin, 1994

Stratford Cairns 1983
On Tuesday evening last a terrible fate befell James Mason, aged 10 years. The father, Mr J E Mason of Stratford and his two bright healthy sons were bathing in the Barron River. They were in about 2 feet six of water. The sandy muddy spot was their favourite spot. They thought they were safe from crocodiles in the shallow water.

Suddenly came a splash. The mud was stirred up and the water lashed. The father's surprise turned to horror. He could not see his eldest boy, Jimmy. He threw the other child on the bank and dived where he had seen the splash. He found the boy and grasped his legs. Something more powerful was pulling the boy away. Then the father realised that a crocodile had taken his boy from his very side.

A few minutes later the crocodile rose to breathe in the middle of the river. In those fearful jaws was one leg of the unfortunate child.
from Cairns Post 21st January 1893.

Daintree River Queensland 1985
A woman was taken by a crocodile during a midnight swim in the Daintree River last night. Beryl Wruck, 43, disappeared without a sound as she splashed in the shallow creek. She and several other party-goers were cooling off after an evening of dancing and drinking.

"There was a huge swirl. I was pushed aside," said one of the swimmers who was standing next to Beryl. "Beryl went up in the air and over and then she was gone. There was no sound, no scream. It was so quick." The party-goers, all Daintree residents, knew that crocodiles had been seen in the creek. They thought they would be safe at low tide. The water was only 45cm deep.

Experts believe the attack was a typical crocodile ambush. Beryl, crouched down in the water, appeared to be a small prey for the 5m crocodile.

"I saw a long dark object with a scaley back rise to the surface of the water," said another swimmer. "She made no sound. There was no blood."
from Mossman Gazette December, 1985

Crocs shot in Daintree 1986
People have been shooting and baiting crocs in the Daintree River since Beryl Wruck disappeared, last December. "Dead crocodiles have been found in the river. Irresponsible shooters hit anything that moves" said one resident. Some people fear that the crocodile that took Beryl will attack again.

"All I want to do is catch the killer croc," said one of Beryl's friends. "I don't want to wipe them all out. " Tourist operators, who run crocodile-spotting cruises in the Daintree River, think that crocodiles should stay.

"People can live with crocodiles safely if they use commonsense," said one tour guide. "You just don't go into the water, especially not at night. Poor Beryl broke the rules. You cannot blame the crocodile."
from Mossman Gazette, February, 1986

Yorkeys Beach Cairns 1997
A 35 year old man was lucky to be alive after he survived a crocodile attack at Yorkeys Beach on Friday night. Ron Bakx suffered deep puncture wounds to the head, back and shoulder in the attack. Mr Bakx, still in shock, said he could not remember seeing the crocodile.

"I'd been at a break-up party and we carried on down to the beach. I went for a dip to cool off," he said. He was in waist deep water when he dived and felt a sudden 'chomp'.

"I felt myself being dragged along. I reckon I was in his mouth a few seconds, " he said. "I started lashing out - it was all pretty quick. I remember thinking `I'm a goner', but then the crocodile had gone."

Mr Bakx has lived in the far north for 10 years and admits swimming at night was a stupid thing to do. "Its their territory. I was doing the wrong thing. Its just one of those things, I guess. No one really thinks it will happen to them."
from Cairns Post, January, 1997

Cairns 1998
A 15 year old girl was mauled by a crocodile in Chinaman Creek, close to the Cairns city centre last night. The girl was at a `beer party' at a nearby camp. She went to the creek to swim when the 3m crocodile grabbed her leg. She was dragged underwater for several minutes. Then she caught hold of an overhead mangrove branch.

Two friends heard screams and raced to help. One young man climbed onto the branch and pulled her up by her hair. He passed her to the other man who had waded into the creek up to his chest. The crocodile still had the girl's legs in it's jaws. The man then had a `tug of war' with the crocodile as it tried to pull the girl under the water.

The other man yelled and splashed to distract the crocodile. The bleeding girl was finally hauled from the water. Police praised the men for their bravery. They said the attack highlighted the danger of swimming in or hanging around crocodile habitats. Food scraps from the camp are believed to have attracted the crocodile to the area.
from Cairns Post, 7 February, 1998

23 October 2002
Kakadu Northern Territory

Sandy Billabong south of Jabiru. According to a police spokesman shortly after the attack. A group of tourists entered the water at Sandy Billabong despite Crocodile warning signs that were posted at and on the way to the Billabong.

It was at 11.30 at night and there was a full moon. It had been a hot day and the night was hot as well. The group were swimming about 10 metres from shore when one of the group felt something bump his leg, he then saw a large dark shape take the woman under the water.

The following day Wildlife officers found the womans body some 2 kilometres from the attack site. The Crocodile responsible was guarding the body, Wildlife officers harpooned the animal and killed it. A larger Crocodile was also in the same spot.

Although this is an incredibly sad thing for the girls family in Germany it is another attack that could have been avoided. Be aware that in Northern Australia that Saltwater Crocodiles are prolific in numbers and it is simply not worth the risk to swim in the creeks, rivers and billabongs.

Local people can play down the risk and the tourist brochures won't tell you much. Oz Magic the Web-Site wants our customers and visitors to Australia to go home with good memories not minus a leg, arm or to die in our country.
Crocodiles have not been hunted in Australia for over 30 years, the small crocodiles from 30 years ago are now large Crocodiles and there are plenty of them out there.

23rd October 2002
North Of Cooktown Queensland
On the same day as the above Kakadu fatality 2 men in a small aluminium boat were fishing north of Cooktown. A large 5 metre Crocodile approached the boat and showed interest. One of the men took a photo just before the crocodile attacked the boat slicing through the aluminium hull with its teeth. The men escaped unharmed.

As a rule Crocodiles don't attack boats, what prompted this particular Crocodile to do so is a mystery to the author of Oz Magic.

25th November 2002
Groote Eyelandt Gulf of Carpentaria
A 29 year old off duty Policeman was spearfishing off Groote Eyelandt when he felt a pain in his back. He then saw a Saltwater Crocodile swim past him from behind. He sought refuge on a coral outcrop and 10 minutes later he saw the Crocodile swim away. This guy was very lucky, the only injury he sustained was a 3 centimetre gash on his back.

Again this could have been avoided.

14th September 2003
Patonga Aboriginal community outstation, about 200km south-east of Darwin
A 10 year old Aboriginal girl felt a crocodile brush against her legs moments before being attacked in a Billabong near Potonga Community in the Northern Territory.

Theresa Richardson-Nagawalli suffering a 20cm gash and cuts to her right thigh. She said there was a big swirl of water before the crocodile attacked. "I saw something coming underneath my legs," she said. "And I sort of felt this rough thing on my leg."

The attack happened on Saturday in a billabong near the Patonga Aboriginal community outstation, about 200km south-east of Darwin.

Theresa's aunt, Elizabeth Ritchie, 33, said her niece and six other children had been swimming unsupervised just metres from the bank.

"The crocodile sort of surfaced right beside her," Ms Ritchie said. "She met him face to face and she looked him in the eye - that is a pretty scary experience. "Then it went under and bit her on the leg - then it quickly let her go."

Theresa swam to the edge and ran 100m to her house before she was airlifted to Darwin.

The 2.15 metre crocodile was shot and killed.

23rd December 2003
Finnis River 80 kilmetres south west of Darwin Northern Territory
3 Teenage boys quad biking stopped to wash the mud off themselves in the Finnis River which was flooding due to a recent cyclone. Brett Mann a diesel mechanic from Darwin slipped into deeper fast flowing water and his friends Shaun Blower & Ashley McGough swam to his aid.

Ashley and Shaun saw the 4 metre crocoile and Ashley screamed out a warning before he and Shaun climbed into the top of a tree that was partially underwater. Neither of them saw Brett taken but as they looked for their friend the Crocodile surfaced with Bretts body in it's mouth and seemingly waved the boys body in the direction of the other two while looking at them.

The Crocodile swam away with Brett. The Crocodile returned a short while later circling the tree and eyeing the boys trapped in the top of the tree. The boys spent the night in the tree before they were found by searchers and air winched by a helicopter to safety.

Authorities are still looking for Bretts body and the Crocodile.

There has been no report of either being found some 3 days after the attack.

Oz Magic offers our condolences to the family of Brett Mann.

Oz Magic Note:
The Finnis River is well known for being home to large Crocodiles. In the "dry season" the rivers dries up into a series of separate Billabongs with very high steep banks. In the "wet season" it can turn into a fast flowing river joining all the billabongs together.

The author of this section has been invited fishing on a property at Batchelor that the Finnis River runs through. After being shown the tiny 2 man boat he was to go fishing in Gary refused the invitation.

The Billabongs had a creepy feeling about them and the knowledge that large Crocodiles could be anywhere just made the fishing trip in a tiny 2 man wooden boat seem not worth the risk. A large crocodile could easily snatch a person from this boat as they sat in it.

Oz Magic urges all visitors and locals to start taking the threat of Crocodile attack seriously. They have been protected for over 30 years and in 30 years a Crocodile will

grow to a very large size, which means there are numerous large Crocodiles in Northern Australia. With a little caution and common sense nearly all Crocodile attacks can be avoided.

11th October 2004
Far North Queensland
Bathurst Bay 250 klms north of Cooktown
Andrew Kerr was in a tent with his wife and baby 40 metres from water when he was dragged from the tent by a 4.2 metre Saltwater Crocodile. Mrs Kerr said she was awoken by a thud to see the Crocodile at the entrance to the tent just standing there. Andrew woke up and the Crocodile lunged and grabbed him by the legs dragging him out of the tent as his wife held onto his hand and their childs basinet the crocodile was dragging all of them out of the tent.

60 year old grandmother Alicia Sorohan and her husband alerted by the screams rushed to the nearby tent to see Andrew being dragged towards the water by the Crocodile. Mrs Sorohan immediately jumped onto the Crocodiles back and the Crocodile instantly turned and grabbed her by the arm, fortunately there was a gun handy and Alicia's son Jason shot the Crocodile in the back of the head ending the attack. Both victims suffered multiple wounds and were evacuated by helicopter after their radio distress signals were picked up by quarantine officers working in the area.

The male Crocodile was estimated to be around 50 years old. Had a gun not been available this could have turned into a tragedy.
Click here for article scan (Courier Mail 12/10/04)
Click here for article scan (Courier Mail 13/10/04)
If picture shrinks hold your mouse over pic and click on box that appears

17th August 2005
Lakefield National Park - Cape York Peninsula
60 year old Townsville railway shunter Barry Jeffries was dragged from a canoe while fishing with his wife in Lakefield National Park on Cape York Peninsula in Far North Queensland. His wife Glenda swam to safety. Body has not yet been recovered but rangers have shot a large Saltwater Crocodile believed to be the animal responsible. Oz Magic advises that canoes are not suitable in tidal coastal areas anywhere in Northern Australia. Had these people not been in a canoe this attack might not have happened. 18/08/05 Updated news reports now say the Crocodile shot was not the one responsible so rangers are once again searching for the Crocodile.
Click here for article scan (Courier Mail 18/08/05) If picture shrinks hold your mouse over pic and click on box that appears

26th September 2005
Picnic Beach - Groote Eylandt Gulf of Carpentaria
POLICE are hunting a four metre crocodile believed to have killed a British national who had been snorkelling off a remote Northern Territory island.

The body of 37-year-old mines superintendent Russell Harris was found yesterday morning after he failed to return from a snorkelling trip off Groote Eylandt, off Arnhem Land. Alyangula police said a saltwater crocodile had been sighted at the mouth of Eight Mile Creek, near where his body was found. Acting Senior Sergeant Stephen Pfitzner said Mr Harris may have been the victim of a crocodile attack, but this had not been confirmed. "Police advise the community that the crocodile may still be in the area and to take extra

precautions if venturing into the waters around Groote Eylandt," he said.

Mr Harris' body was flown to Darwin today for a post mortem examination. A police spokeswoman said police would hunt the crocodile and attempt to move it to another location. Police said Mr Harris had been snorkelling with another man off rocks, about 100 metres north of Picnic Beach, on Saturday whilst their partners remained on the beach. At some point the two men became separated.

The other man last saw Mr Harris about 2pm, snorkelling about 20 metres from shore. He became concerned when Mr Harris still had not returned by 4pm, and he contacted police. After an extensive search, the 37-year-old's body was found early yesterday morning, about 1.5 km north of where he was last seen. Police did not reveal until later their belief that Mr Harris was killed by a crocodile.

29th September 2005
Coburg Penninsula Northern Territory
A 56 year old man scuba diving on the Coburg Penninsula was found dead with wounds consistent with being attacked by a large Crocodile.

9th July 2006
Crocodile takes young girl in Northern Territory
An eight-year-old girl is feared dead after being taken by a saltwater crocodile in the Northern Territory.

Police say the girl was fishing with her family in the Blythe River between Maningrida and Ramingining, in Arnhem Land, east of Darwin, when the attack occurred about 8.30pm (CST) Saturday.

"It's believed she went to the water's edge to collect water when she was taken," a spokeswoman said.

"Members of the tactical response section and parks and wildlife rangers will be attending the area to search for the girl and attempt to harpoon the crocodile." The spokeswoman said they had not been able to ascertain where the girl was from, with the family fishing from a small outstation on the river. It was not known how large the crocodile was, but it was likely the girl had not survived the attack, police said.

A police spokeswoman later said the search was unlikely to start until nightfall. She said police tactical response officers and parks and wildlife rangers were still travelling from Darwin to the remote search site. "They'll look at searching on dark - that tends to be a better time to look for crocodiles," she said.

A spokesman for the Northern Territory's environment department said senior wildlife officers had left Darwin just after midday.
"Normally what happens is the location and recovery of the body is first and foremost priority," he said."Then, of course, it is to determine which particular crocodile might have been responsible for this.

"If the crocodile is able to be isolated and identified it becomes a decision whether to relocate it to a crocodile farm or if it's likely to pose a threat, killing it might be an alternative option as well."

8th November 2006
Cape Tribulation Belgian Tourist Bitten
A Belgian tourist was bitten on the knee today by a 2 metre saltwater crocodile at Cape Tribulation north of Cairns. The man was attempting to obtain a photo of the crocodile and despite crocodile warning signs in the area he splashed the water to attract the crocodile closer to get the photo. The crocodile charged out of the water and bit him on the knee. The man is recovering in hospital.

8th January 2007
An off duty police man was attacked by a 3 metre crocodile while snorkeling with his wife on a reef off Thursday Island north of Cape York Queensland. The crocodile attacked him, dragged him under the water and then released him. Sergeant Jeff Tanswell survived the attack.

9th January 2007
Kerry York attacked twice by an unidentified species of Crocodile at Kununurra in the Northern Territory. Kerry survived the attack relatively unscathed requiring stitches to wounds and not requiring hospitalisation.

30th September 2008
An elderly man is suspected killed by a large crocodile this morning. 62 year old Vietnam veteran Arthur Booker had been camping with his wife near the banks of the Endeavour River when the man went to check crabpots about 8.30am. When he had not returned by 10.00am the mans wife went to the river bank to find a broken crab pot rope, the mans video camera on the ground and large crocodile slide marks in the mud. Authorities are still searching for the mans body. A number of 4 metre saltwater crocodiles have been sight in the area. It is believed the couple were from Brisbane, the man's wife is being treated for shock in hospital.
2nd October 2008 update
Searchers looking for Mr Booker have found two of his sandals and his wristwatch, the search continues. Charlie a 5 metre saltwater crocodile who lives in the area is the prime suspect but two crocodile nesting sites have been found only 400 metres from where Mr Booker disappeared. Mr Bookers family have flown to Cooktown to give support to Mrs Booker and to assist in the search. Spokesman for the family says they are still hoping for a miracle.
13th October 2008 update
Adult human male remains have been found in one of three large saltwater crocodiles caught in the area where Arthur Booker disappeared. Police say further DNA testing is being conducted.

8th February 2009 - 9.30am
5 year old Jeremy Doble taken by a large crocodile in the Daintree River Queensland. The attack was witnessed by the victims brother who raised the alarm with their father. The crocodile is suspected to be a crocodile called “Goldie” a dominant male living in a swamp near the families home. No trace of Jeremy has been found yet.

March 2009
Eleven year old girli taken by a large crocodile while swimming at Black Jungle Billabong near Darwin while with friends. Billabong is a permit only area they were not supposed to be there. Her remains were found later

March 18 2010

Diver attacked by crocodile and survived. He was attacked by a 3 metre crocodile while diving for trepang on the remote Coburg Penninsular. Fellow divers pulled him aboard the boat after he was attacked and he was taken to Darwin Hospital.

February 6th 2011
Man fights off 2.5 metre saltwater crocodile by punching it many times after it grabbed his other arm at Beening Creek at Napranum near Weipa in North Queensland. Area is well known to have a lot of Saltwater Crocodiles resident.

February 20th 2011
Milingimbi Island Northern Territory
A 14 year old boy was taken by a saltwater crocodile while playing at a creek with his brothers. There has been no sign of the boy despite a search by community members.

9th March 2011
A fisherman has survived a crocodile attack by clinging to mangroves in a creek in far north Queensland, police said. Twenty eight-year-old mine worker Todd Bairstow was fishing on the bank of Trunding Creek, Weipa, about 4pm yesterday when the crocodile attacked.

Oz Magic Note:
Dr Graham Webb the Northern Territory's leading expert on Saltwater Crocodiles recently stated that Saltwater Crocodile numbers have returned to the numbers found 200 years ago. All visitors to tropical areas in Northern Australia should use extreme caution when near water in Northern Australia.

REVIEW

Crocodile Attack in Australia: An Analysis of Its Incidence and Review of the Pathology and Management of Crocodilian Attacks in General

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Crocodilians represent one of the oldest constant animal lineages on the planet, in no small part due to their formidable array of predatory adaptations. As both human and crocodilian populations expand, they increasingly encroach on each others' territories, bringing morbidity and mortality to both populations. In this article, the medical and herpetologic literature pertaining to injuries caused by crocodilians is reviewed, and the patterns of saltwater crocodile attacks in Australia from 1971 to 2004 are analyzed. In this review, we examine the features of crocodilians that contribute to explaining their evolutionary success, as well as the potential hazard they pose to humans. Only by understanding their capabilities is it possible to mitigate the potential threat to life and limb.

Key words: crocodile, alligator, attack, bite, Australia

How doth the little crocodile
Improve his shining tail,
And pour the waters of the Nile
On every golden scale!
How cheerfully he seems to grin,
How neatly spreads his claws,
And welcomes little fishes in,
With gently smiling jaws!

—Alice in Wonderland *by Lewis Carroll, 1866*

Crocodilians are among the few species on the planet that cause reflexive fear in humans, perhaps because the fear of being eaten is greater than the fear of being bitten.[1] Many animals will bite, but only a few attack humans as they would other prey items. Fortunately, attacking and eating humans by crocodilians is an uncommon event. We review the features of crocodilians that make them such formidable predators, examine the incidence of saltwater crocodile attacks in Australia, and examine the pathology and management of this entity.

The order Crocodylia comprises 23 species of extant crocodilians within 3 families: Alligatoridae (8 species; alligators and caimans), Crocodylidae (14 species; "true" crocodiles), and Gavialidae (1 species; Indian gharial)[2] (Figure 1). Crocodylomorpha, the broad taxonomic grouping that encompasses crocodilians and their known predecessors, can be traced back approximately 240 million years and has diversified into terrestrial, freshwater, and marine environments. The modern Crocodylia originated more than 100 million years ago, and its members have remained relatively unchanged since then. Crocodilians share their early archosaurian origins with dinosaurs and hence are more closely related to birds than other reptiles.[3] The word *crocodile* is derived from the Greek word *krokodeilos*, which translates literally into pebble worm (*kroko* means pebble and *deilos* means worm or man), presumably referring to the appearance of a crocodile's skin. The word *alligator* comes from the Spanish for lizard, *el lagarto*.[4]

Modern crocodilians are geographically widespread in warm temperate and tropical climates.[5] The 2 species of alligator, the Chinese alligator (*Alligator sinensis*) and the American alligator (*Alligator mississippiensis*), are distributed in more temperate climates and are exposed to relatively cold conditions during winter.

It would seem that humans may have always had a healthy respect for crocodilians, judging by the paleon-

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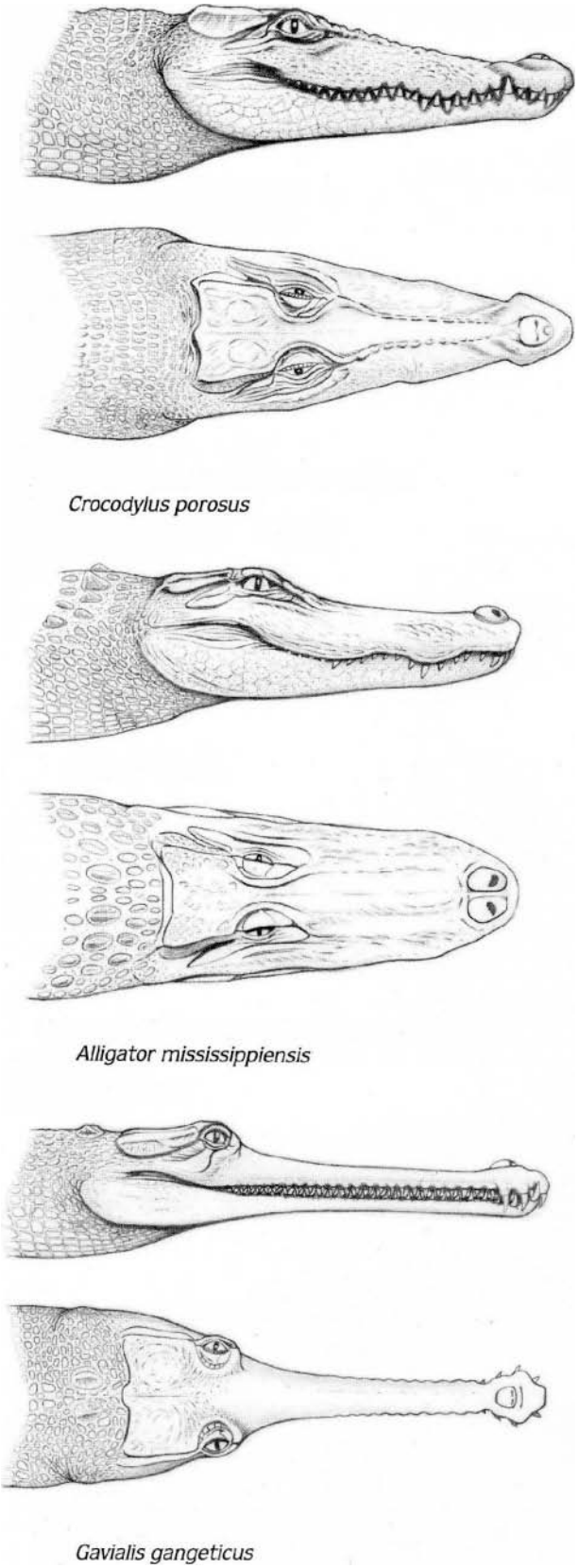

tologic evidence that suggests that crocodilians preyed on human ancestors.[6] Crocodilians feature in the traditions and myths of many cultures around the world. For example, crocodiles (*Crocodylus porosus*, *Crocodylus johnstoni*) figure prominently in the dreamtime stories of a number of aboriginal clans in northern Australia[7–9] and are of totemic significance to this day. To the Iban people of northern Borneo, it is taboo to kill crocodiles, except where one has killed a human.[10,11] The *Por* people of the Cardomom Mountains in Cambodia revere Siamese crocodiles (*Crocodylus siamensis*), and the killing of one is believed to cause an ancestor's forest spirit to bring illness and death to the person or family responsible.[12] In ancient times, Nile crocodiles (*Crocodylus niloticus*) in Egypt were worshipped and associated with the crocodile-deity Sobek, at the shrines of Kom-Ombo in Upper-Egypt, and in Crocodilopolis (Fayum).[13] The crocodile was thought to be responsible for the rains that overflowed the Nile River and left behind the rich mud that fertilized the land. At the same time, they were feared for their destructive power.[14,15] Early explorers reported the fear that Native American Indians showed toward alligators.[16]

More recently, humans have had the advantage. The overexploitation of crocodilians for their skins after World War II resulted in two thirds of the species being placed on Appendix I of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) in 1973.[17] No international trade is permitted under Appendix I (except animals derived from registered captive-breeding operations). Today, because of the efforts of conservationists, researchers, skin traders, and others, many crocodilian populations around the world have recovered.[18] The success of many of these management programs has led to increased interactions and conflicts between people and crocodilians, often promoting a negative reaction to their successful population recovery. In some countries, wildlife authorities have specific programs to remove nuisance alligators or problem crocodiles to improve public safety (eg, Australia, United States, Zimbabwe).

With regard to unprovoked attacks on humans, 3 species are perhaps the best known—the American alligator, the Nile crocodile, and the saltwater or estuarine crocodile (*C porosus*). A number of other crocodilian species have been less commonly implicated in attacks

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Figure 1. Dorsal and lateral views of a true crocodile (saltwater crocodile, *Crocodylus porosus*), alligatorid (American alligator, *Alligator mississippiensis*), and gavialid (Indian gharial, *Gavialis gangeticus*). Adapted from Webb and Manolis.[8]

on humans, including the black caiman (*Melanosuchus niger*),[19,20] Morelet's crocodile (*Crocodylus moreletii*),[21–23] American crocodile (*Crocodylus acutus*),[24,25] mugger (*Crocodylus palustris*),[25] and the Indian gharial (*Gavialis gangeticus*).[26] Two cases of directed attacks by Australian freshwater crocodiles (*C johnstoni*) (in 1988 and 1990)[27] appear to have been cases of mistaken identity, since this species is generally considered harmless unless provoked.

The incidence of crocodile attacks in many countries is extremely difficult to quantify. Undoubtedly, many more people have been attacked by crocodilians than have been reported. At the turn of the century in the United States, current thinking was that crocodilians would not attack humans unprovoked.[28–30] This widely accepted opinion changed in 1973 with the death of a 16-year-old girl attacked by a 4-m-long alligator.[31] Since then, more detailed records on alligator attacks have been kept,[32] although with nowhere near the accuracy or detail of the record keeping of other animal attacks, such as the International Shark Attack File. The worst mass attack by crocodiles was said to have been on the night of February 19, 1945, when allegedly approximately 1000 Japanese soldiers found themselves pinned down in a mangrove swamp separating Ramree Island from the Burmese mainland. According to the British naturalist Bruce Wright, who was then a member of the British Armed Forces, only 20 Japanese allegedly escaped alive from the saltwater crocodiles.[33] The veracity of this report has subsequently been called into question.[34] A 5.8-m-long saltwater crocodile (named Whiteback due to distinctive white markings on his back) gained considerable notoriety in Sarawak, Malaysia, after killing 13 people.[35]

Accurate data collection concerning animal attacks does not usually occur until a species is protected and formal monitoring is introduced. The situation with saltwater crocodiles in northern Australia is no exception, and most detailed information on attacks has been recorded since the species was legally protected in the states or territories in which it occurs (Western Australia in 1969, Northern Territory in 1971, and Queensland in 1974).[8] Even so, detailed information on some attacks is not always available, and attacks that do not result in injury are not usually recorded.

A review of crocodile attacks in northern Australia would not be complete without a brief summary of the features of crocodilians that make them such formidable predators.

The crocodile as a predator

Crocodilian notoriety stems in part from their prominent teeth, the number of which varies between species.[36] Saltwater crocodiles possess between 64 and 66 teeth: 17 to 18 teeth on each side of the upper jaw (premaxilla and maxilla) and 15 on each side of the lower jaw (mandible). Designed to grab and hold onto prey, the teeth are constantly replaced through the animal's life. Massive pterygoid muscles[37] close the jaws with enormous force, and being bitten has been described like being hit with a hammer, patients often only realizing later that they have sustained a penetrating injury. Even bites from small specimens can have serious consequences.

Recently, investigators measured the bite force of various crocodilian species, with particular attention to series of different sized American alligators and saltwater crocodiles. These results indicated that a 300-kg, 3.65-m-long American alligator could exert a force of just under 1000 kg, equal to the force required to lift a small utility vehicle.[38] Such forces can easily crush turtle shells and have been reported to be able to crush a pig's head with ease.[8] They also found that biting force was proportional to size.

As in most vertebrates, the depressor muscles that open the crocodilian's jaws are much weaker than those that close the jaws, and it is common folklore that a strong elastic band can prevent even large crocodilians from opening their jaws. With relatively undifferentiated teeth, crocodilians waste little time processing prey before swallowing it. The jaws and teeth crush flesh, carapace, and bone enough to render prey small enough to be swallowed. Larger prey items are broken into smaller chunks by rolling the entire body (termed the *death roll*) and also by using a whipping action of the head.[39] Contrary to what might be assumed by their large size, crocodilians are surprisingly agile and explosively fast over short distances. Some species have been observed ''galloping'' at speeds up to 17 km/h (10.6 mph),[40] and even large crocodilians can move rapidly across land at speeds of up to 10 km/h (6.2 mph). The ability to move very quickly over a short distance (eg, an entire body length in less than half a second) contributes to their success as ambush predators.

Most adult crocodilians are threatened only by other crocodilians and humans. Generally, the larger species of crocodilians see humans as a potential food source. The average maximum size of male saltwater crocodiles is 5 m, and some individuals may exceed 6 to 7 m.[10,41] Nile crocodiles typically average 3.5 m in length, although some males may reach 5 m.[42] Male American alligators average approximately 3 m, and some occasionally reach 4.5 m.[43]

The success of crocodilians as predators is due largely to the shape of their body and their ability to expose only a small part of it (the head), while the bulk of the body remains hidden underwater. The positioning of the

internal nares behind the palatal valve and the development of a secondary palate have been instrumental in their success, enabling this minimum exposure posture of eyes, ears, and nostrils above water that lends a crocodilian its stealth profile.[8] A palatal valve at the back of the tongue serves to seal the mouth off from the palate and trachea, enabling the jaws to be opened fully underwater without allowing water to enter the throat and trachea.

This minimum exposure posture leaves the well-developed sense organs exposed and continually sensing the environment.[36] Daytime vision is good, and night vision is enhanced by a layer of guanine crystals in the retina (the tapetum lucidum) that reflect light that enters the eye back over the visual sensory cells a second time.[36,44] Crocodilian hearing apparatus is the most developed of all reptiles, and its sensitivity is on a par with most mammals. Research has also shown their olfactory and gustatory senses to be highly developed. Recent studies of sense organs in the skin around the jaws (dermal pressure receptors) show the organs' ability to detect very subtle pressure changes in the water—alligators could detect a droplet of water hitting the surface near their head through the resulting pressure waves alone.[45]

Crocodilians can remain underwater for extended periods, which allows them not only to drown prey but also to remain concealed. The amount of time that an animal can stay underwater without surfacing increases with increasing body size. Although most crocodiles stay underwater for an average of 15 minutes per dive, large crocodiles (>4 m in length) are able to stay underwater for up to 2 to 3 hours.[46] Following a voluntary dive, heart rate decreases markedly and can drop to as low as 1 to 2 beats/min. Unlike other reptiles, crocodilians have a 4-chambered heart that possesses unique valves both within the heart (cog valve) and in the twin aortas leaving it (foramen of Panizza).[47] The heart's structure serves to divert oxygenated blood flow away from peripheral and nonessential organs during diving, maximizing available oxygen to the brain and other vital organs. Crocodilian hemoglobin has 12 unique bicarbonate binding sites, allowing far more oxygen to be released from the molecule for a given oxygen tension than from the human equivalent. A hybrid human-crocodilian hemoglobin (Hb-Scuba) has been developed and has potential as a synthetic hemoglobin.[48]

One characteristic that is relevant to the analysis of crocodile attacks is that crocodilians will intentionally eat stones, which are stored within the stomach. These stones appear to act as gastroliths to assist in the breakdown of ingested food,[8] although a hydrostatic function has also been suggested.[49] The propensity of crocodilians to retain heavy objects in the stomach means that items such as bullets and lead shot imbedded in prey or carrion remain in the stomach well after the food has been completely digested. A coroner's examination of crocodilian stomach contents that contain human remains may become ''complicated'' if such items are also present (Figure 2).[8]

Literature review methods

A review of the available literature on Australian crocodile attacks was completed from a variety of sources. The extensive records at Crocodylus Park (Darwin, Northern Territory) were cross-referenced against a Nexis/Lexis and NewsText electronic search of newsprint articles. Crocodile attack has only been coded as a separate injury mechanism since the introduction of the *International Classification of Diseases, Tenth Edition* in 1997, but data from the National Injury Surveillance Unit were further cross-referenced to the newsprint data. The medical literature was searched using the PubMed database for all references to *crocodile* or *alligator.* The herpetologic literature was searched using the Biosis Previews, Zoological Record, and Wildlife and Ecology Studies Worldwide databases for crocodile or alligator attacks. Finally, the Google search engine was used to search for all instances of *crocodile attack* or *alligator attack.* All references obtained using this search strategy were then subsequently hand searched for further relevant references.

Analysis of attacks

There have been 62 definite, unprovoked attacks by wild saltwater crocodiles, resulting in injury or death to humans, between 1971 and 2004 (Table 1). One attack on a researcher (collecting crocodile eggs, 1986), 2 attacks on wildlife rangers (capturing crocodiles, 1993 and 2002), and 1 attack on a crocodile farmer (collecting crocodile eggs, 2004) that occurred during their work with wild crocodiles were excluded. Likewise, attacks by captive crocodiles were excluded from the analysis.

The Northern Territory, which contains the largest wild population of saltwater crocodiles within Australia, has accounted for most (63%) attacks, followed by Queensland (24%) and Western Australia (13%) (Table 1). Notwithstanding the relatively low number of attacks during the 34-year period, there has been a tendency toward increasing numbers of nonfatal attacks over time (from 0.1 per year in 1971 to 1980 to 3.3 per year in 2001 to 2004) and relatively stable numbers of fatal attacks over time (mean, 0.5 per year) (Table 2).

The wild population of saltwater crocodiles in the Northern Territory has increased from an estimated 3000

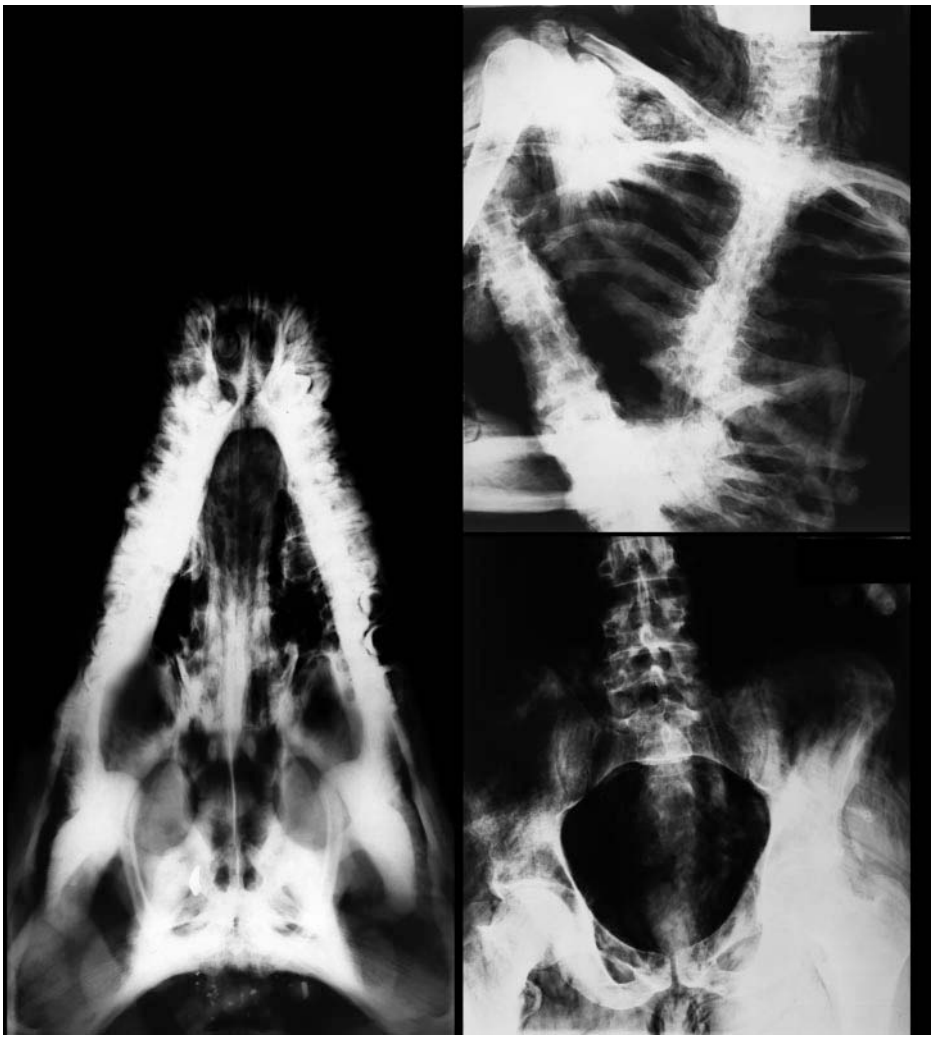

Figure 2. Radiographs of postmortem *Crocodylus porosus* and *Homo sapiens* (to similar scale). In the circumstances of this case, it was important to establish whether the victim had been shot before having been consumed by the animal. One shot was used by a police officer to dispatch the animal. **Left,** The police bullet can be seen in the crocodile's head. **Right,** The torso has been transected by the force of the crocodile bite, but no additional projectile can be identified.

Table 1. Saltwater crocodile attacks in the wild, in northern Australia, 1971–2004

	No. (%) of attacks			
Attack type	*Northern Territory*	*Queensland*	*Western Australia*	*All states*
Fatal	10 (25.6)	5 (33.3)	2 (25.0)	17 (27.4)
Nonfatal	29 (74.4)	10 (66.7)	6 (75.0)	45 (72.6)
Total	39 (62.9)	15 (24.2)	8 (12.9)	62

to 5000 in 1971, when the species was protected after 26 years of unregulated hunting, to 50 000 nonhatchlings in 1984[50] and 75 000 nonhatchlings in 2000.[51] The recovery of the population has been characterized by a marked increase in the average size of the saltwater crocodile in the population.[51] Whether the increased numbers of crocodiles and greater numbers of large crocodiles are implicated in the increased frequency of attacks is unclear. Andau et al[52] concluded that the increased number of saltwater crocodile attacks in Sabah, Malaysia, were the result of increasing numbers of crocodiles. Glasgow[53] relates how increasing numbers of American alligators and an expanding human population in Louisiana in the 1970s resulted in increased interactions with alligators.

Table 2. Mean number of saltwater crocodile attacks per year in the Northern Territory and Australia

Period	*Fatal*	*Nonfatal*	*Total*
Northern Territory			
1971–1980	0.2	0.0	0.2
1981–1990	0.4	1.0	1.4
1991–2000	0.2	1.2	1.4
2001–2004	0.5	1.8	2.3
Australia			
1971–1980	0.4	0.1	0.5
1981–1990	0.8	1.2	2.0
1991–2000	0.3	1.9	2.2
2001–2004	0.5	3.3	3.8

The reasons why saltwater crocodile attack humans without any provocation are thought to be as follows:

1. Defense of territory: Saltwater crocodiles are highly territorial.[8,54] Males and females establish territories[55,56] and defend them against intruders, whether other crocodiles or humans.
2. Defense of nest and/or young: Most species of crocodilian exhibit some form of nest defense.[54] In the case of saltwater crocodiles, females vigorously defend their nest against intruders to deter potential predators of their eggs. Crocodilians will also react to distress calls of their young.[1,57,58] There are 2 confirmed cases of female saltwater crocodiles attacking humans near their nests; one of these attacks resulted in the death of the victim.
3. Hunting for food: All crocodilians are opportunistic feeders, eating a wide range of prey. With increasing body size, crocodilians shift to larger prey,[49,59] and humans are well within the size range of prey that can be taken by a large saltwater crocodile. Fifty-five attacks in our series (89%) were considered to be attempts by crocodiles to secure food, although the possibility of territorial defense cannot be ruled out in some cases.
4. Mistaken identity: It is possible that some attacks may be directed at dogs accompanying people, and the latter were bitten by mistake. There were 2 cases of people in our series being attacked while sitting near the water's edge with their pet dogs. In one of these attacks, the crocodile was relatively small (1.7 m) and is unlikely to have been attacking the much larger human. Dogs are commonly taken by crocodiles in northern Australia.[60]
5. Self-defense: Attempts to catch crocodiles may result in the animal biting instinctively to protect itself. Only one case in our series was considered a defensive reaction by a relatively small crocodile (1.8 m).

Most (81%) unprovoked saltwater crocodile attacks occurred with people in the water swimming or wading or at the water's edge (Table 3). All fatal attacks involved people in the water, either swimming (73%) or wading (27%). Five attacks (9%) involved people on land, with crocodiles coming completely out of the water. In 2 of these cases crocodiles actually entered tents and grabbed sleeping occupants. Data compiled by Conover and Dubow[32] indicate that 89.7% of victims of 184 unprovoked American alligator attacks (1948 to 1995) were participating in activities where they were totally (39.1%) or partially (22.3%) immersed in water or standing at the water's edge (28.3%); 10.3% were on land (17 cases), on a boat or raft (2 cases), or not recorded (2 cases). In 12 of 16 fatal alligator attacks recorded by the Florida Fish and Wildlife Conservation Commission (unpublished data, 1928–2004), 10 involved victims in the water (swimming or wading) and 2 were on land. The circumstances of the other 4 attacks are not known. Fergusson[61] reported 55.3% of Nile crocodile attack victims were swimming, bathing, or crossing a river with cattle, and 36.2% were collecting water, drinking, or fishing at the water's edge.

Attacks on people in boats and canoes are of particular interest. The first recorded attack in the Northern Territory, in 1870, involved the second mate of a schooner on the Roper River being taken as he slept with his legs hanging over the side of the boat. Since 1971, unsuccessful saltwater crocodile attacks have been directed at people pulling boats out of the water, but in each case the individuals were out of the boat and in the water or at the water's edge. Excluding one attack that may have been provoked (Bynoe Harbour, 1980), few attacks have been directed at people in boats. This consideration is significant because fishing is one of the common pastimes for locals and tourists in northern Australia.

Two specific instances of saltwater crocodiles deliberately attacking boats merit mention. A 5.1-m-long male saltwater crocodile (named Sweetheart) attacked the propellers of the outboard motors of a number of boats, overturning them and their occupants but never attacking the people in the water.[62] It is thought that Sweetheart was probably reacting to the sound of the propellers, which he may have mistaken for another crocodile within his territory.[8] Another large saltwater crocodile (5.1 m) began attacking the warm cowlings of outboard motors after the boats had been pulled up onto the bank. In this case, it is thought that this individual may have interpreted the warmth of the motor as a large mammal at the water's edge.[8] Both of these cases appear

Table 3. Activities of people (62 attacks, 64 people) at the time of attack by saltwater crocodiles, 1971–2004

Activity	*Nonfatal*			*Fatal*		
	Day	*Night*	*Unknown*	*Day*	*Night*	*Unknown*
Water						
In shallow water (hunting, fishing, wading)	12	2	···	2	1	1
In water (skin-diving, spear-fishing)	4	···	···	···	···	···
In water (swimming)	6	3	···	5	6	···
At water's edge	5	1	···	···	···	···
Subtotal (n = 48; 81.4%)	27	6	···	7	7	1
Boats or canoes						
Leaning out of airboat into water	1	···	···	···	···	···
Getting into boat	1	···	···	···	···	···
Boat	2	···	1	···	···	···
Canoe	1	···	···	···	···	···
Subtotal (n = 6; 10.2%)	5	···	1	···	···	···
Land						
Asleep in tent	···	2	···	···	···	···
Asleep on beach	···	1	···	···	···	···
Asleep near water	···	1	···	···	···	···
Near crocodile nest	1	···	···	···	···	···
Subtotal (n = 5; 8.5%)	1	4	···	···	···	···
Unknown activity (n = 3)	···	···	2	···	···	1
Total No. (%)	33 (76.7)	10 (23.3)	3	7 (50.0)	7 (50.0)	2

to be unique and may not be representative of the usual behavior of saltwater crocodiles toward boats.

In the Northern Territory, crocodiles are an important tourist attraction, and crocodile feeding is undertaken by a number of tourist operators. Crocodiles may jump out of the water alongside a boat to take food being offered. More than half the body length of even large (>4 m) crocodiles may be out of the water during such jumps. One study examined the effect of these feeding activities on the behavior of the crocodiles involved and concluded that the crocodiles were attracted to tourist boats, either visually or by the sounds of the motors, and approached them closely. However, they would not approach smaller boats in the same way.[63]

The situation with canoes and saltwater crocodiles is considered different from that with boats. There has been one serious attack on the occupant of a canoe in the East Alligator River in 1986, and several unsuccessful attacks are known.[60,64] In northern Australia, canoeing is not a regular pastime in areas inhabited by saltwater crocodiles, but in other countries where the species occurs, canoes or similar types of watercraft are the main mode of transport. For example, many saltwater crocodile attacks have occurred on people in small perahus (sampans) in the states of Sarawak and Sabah in Malaysia,[10,65,66] but there have been no reports of such attacks on conventional boats of any size. Guggisberg[24] describes how a man in Sudan was taken by a Nile crocodile from a boat as he sat with his legs hanging in the water, but the boat was not the subject of the attack. However, Richardson and Livingstone[67] report an attack on a small boat. Nile crocodiles have been known to attack rubber boats and canoes and ignore the fleeing occupants.[68] Conover and Dubow[32] reported 2 attacks by American alligators, one on someone ''riding a sailboat'' and the other on a person ''lying on an inflatable raft,'' but the exact circumstances are not presented. Neill[29] reported 2 attacks by alligators on himself as he paddled a small pirogue. Why canoes are attacked more readily than other boats is unclear. However, the profile (silhouette) of a canoe viewed from underwater is very different from that of a boat and may resemble another crocodile or animal swimming in the water.

The fact that 70% of attacks in northern Australia occurred during the day is a reflection of people's activities (Table 3). Similarly, Fergusson[61] reported that 86% of Nile crocodile attacks occurred during daylight hours, reflecting human activity patterns. Saltwater crocodile

Table 4. Months in which saltwater crocodile attacks have occurred in northern Australia, 1971–2004

Month	*No. (%) of attacks*		
	Nonfatal	*Fatal*	*Total*
January	1	···	1 (1.6)
February	5	1	6 (9.8)
March	1	2	3 (4.9)
April	3	1	4 (6.6)
May	3	1	4 (6.6)
June	3	1	4 (6.6)
July	3	1	4 (6.6)
August	2	1	3 (4.9)
September	6	1	7 (11.5)
October*	5	3	8 (13.1)
November	7	1	8 (13.1)
December†	6	4	10 (14.8)
Dry-cool season (May to July)			
Total	9	3	12 (19.4)
Attacks per month	3.0	1.0	4.0
Dry-warm season (August to October)			
Total	13	5	18 (29.0)
Attacks per month	4.3	1.7	6.0
Wet-warm season (November to April)			
Total	23	9	32 (51.6)
Attacks per month	3.8	1.5	5.3
All months	45	17	62

*Eight attacks involving 9 people.
†Ten attacks involving 11 people.

attacks have occurred in all months of the year (Table 4), including the cooler months (May to July) when crocodiles are generally less active. Pooley et al[68] indicated that 39 (91%) of 43 attacks by Nile crocodiles in northern Zululand and southern Mozambique occurred between November and early April, when weather conditions are warm, and coincided with the mating and breeding season. Fergusson[61] reported similar results in attacks from Namibia and Kenya, where 78% of attacks occurred in November to May. In Florida, alligator attacks have occurred in all months of the year, but most (75%) took place in the warmer times of the year.[32] In the states of Louisiana, South Carolina, and North Carolina, where winter temperatures are much lower than those in Florida, attacks have only been recorded in the warmer months (May to September)[32] (R. Elsey, written communication, September 2004); alligators are generally inactive and/or aestivating in the cold winter months.

Tourist visitation to northern Australia is strongly seasonal, with 50% or more of visits occurring in a 3-month period (June to August). It is not surprising that the pattern of attacks does not follow monthly trends in visitation, because almost all attacks (95%) have involved people who lived in the area or who visited northern Australia regularly and were aware of the potential danger. Only 2 fatal attacks involved overseas visitors (United States, Germany)[69] participating in tourist-related activities. The nesting season for saltwater crocodiles (October to May)[8] coincides with the wet season, when outdoor activities such as camping and fishing are not undertaken as frequently as in the dry season. (In the Northern Territory, 87% of mean annual rainfall occurs between November and March.[70])

Fatal attacks have generally involved saltwater crocodiles longer than 4 m (Table 5) that have the strength and power required to overpower an adult human. Because females do not grow longer than approximately 3 m, all large crocodiles are males.[8] Nonfatal attacks have usually involved smaller crocodiles (Table 5). Three of 5 nonfatal attacks by crocodiles longer than 4 m have involved victims that received assistance from other people to escape; the attacks would otherwise have resulted in death. The difference in bodyweight between the salt-

Table 5. Mean, minimum, and maximum estimated total lengths and sex of saltwater crocodiles involved in attacks in northern Australia, 1971–2004

Attack type	*n**	*Total length of crocodile, m*					
		Mean	*Minimum*	*Maximum*	*Male*	*Female*	*Unknown*
Fatal	14	4.3	2.7	5.1	12	1	1
Nonfatal	32	3.0	1.7	5.0	9	1	22
All	46	3.4	1.7	5.1	21	2	23

*Sample sizes on which means are based.

Table 6. Age and sex of saltwater crocodile attack victims in northern Australia, 1971–2004*

Age, y	*Male*	*Female*	*All*
1–10	1	3	4
11–20	4	2	6
21–30	11	3	14
31–40	12	3	15
41–50	3	1	4
51–60	1	3	4
61–70	...	...	...
71–80	1	...	1
Unknown	15	1	16
Total	48	16	64
Mean	31.8	29.9	31.2

*The 62 attacks involved 64 people.

water crocodiles involved in nonfatal (3.0 m) and fatal (4.3 m) attacks is great: 100 kg compared with 350 kg.[8,71] Nonfatal attacks by Nile crocodiles have also involved smaller (2.5 m) animals.[68] The mean size of American alligators involved in fatal attacks is 3.0 m[32] (Florida Fish and Wildlife Conservation Commission, unpublished data, 1928–2004), with animals ranging in size from 1.8 to 3.7 m. The smallest alligator in the series killed a 2-year-old child, and it is unlikely that it would have been able to overpower an adult. Compared with the situation with saltwater crocodiles, relatively small (0.3 to 1.5 m) alligators have been involved in unprovoked, nonfatal attacks,[32] which probably reflects the different levels of wariness between the 2 species.[54]

Most attack victims in northern Australia have been males (75%), and the average age of all victims is 31.2 years (Table 6). A similar trend is apparent with American alligator attacks (1948 to 1995), where 84% of victims were male, and the average age of victims was 31.8 years.[32] A lower proportion of males (59%) was reported for Nile crocodile attack victims.[61]

It is difficult to compare the frequency of crocodile attacks between species and/or countries, largely because of the lack of reporting in many countries, particularly in Africa. Since 1980 (24.4 years), 42 attacks (fatal and nonfatal) by saltwater crocodiles have occurred in Sarawak, Malaysia,[72] compared with 56 attacks during the same period in northern Australia. Nile crocodiles kill many more people in Africa than do saltwater crocodiles throughout their range. For example, from January 2000 to March 2004 (4.25 years), 23 people were killed and 12 people were injured by Nile Crocodiles in Namibia,[73] and during 2.3 years (January 2002 to April 2004), 40 people were killed and 8 people were injured in Zambia.[74] A preliminary review of attacks by Nile crocodiles, with most records from Kenya and Namibia and for the period of 2000 to 2004, revealed 98 instances.[61]

The fatality rate in one American alligator series was 5.8%[75]; in another series of attacks that involved the same species (184 attacks; 1948 to 1995), 8 fatalities (4.3%) occurred.[32] The Florida Fish and Wildlife Conservation Commission's records indicate a fatality rate of 6.6% (16 of 242) for unprovoked alligator attacks in Florida (1948 to mid-2004) but consider this an overestimate, because minor injuries that do not require medical attention are more likely to have been recorded in recent years than previously. These rates are lower than the 27.4% for our series of attacks by saltwater crocodiles in northern Australia (Table 1), the 50% mortality rate reported in Sarawak, Malaysia,[11] and the 36% reported in Sabah, Malaysia.[76] The relatively high fatality rate due to Nile crocodiles in Namibia (66%)[73] may be overestimated, because minor injuries from attacks, particularly in remote areas, tend not to be reported (P. Lindeque, written communication, September 2004). The same may apply to Zambia (83%),[74] with perhaps as many as 80% of minor, nonfatal attacks not being reported (G. Kampamba, oral communication, September 2004). As a result, the fatality rate (63%) reported by Fergusson[61] for Nile crocodiles may also be overestimated.

Medical literature

The medical literature on crocodilian attacks remains scanty, limited to 2 larger series from northern Australia (16 patients)[77] and southern Malawi (60 patients)[78] and a number of case reports.[79–88] Some additional series and case reports can be found in the herpetologic literature,[19,26,86,88,89] and various accounts of attacks that describe injuries are in the general literature.[10,24,29,54,76,90,91]

In the Australian series,[77] 16 cases are reported (13

men and 3 women) with 4 fatalities. Eight persons (all fatalities) were intoxicated; 10 attacks occurred in low light or at night; 11 occurred in the wet season; half occurred in remote areas, more than 150 km from the treating hospital; and more than half of the survivors developed significant wound infections.

In the Malawian series of 60 cases during a 4-year period, a similar male predominance is observed: 47 males, 10 females, and 3 children (sex not provided) were attacked.[78] The average age was 37 years, with a range of 9 to 70 years. Less than half of the individuals[28] arrived at the hospital within 24 hours of the injuries being sustained. Patients underwent an average of 4 surgical procedures each, and 40% of all discharged were left with ''permanent deformities.''

The true number of global crocodilian attacks and the associated medical burden are difficult to quantify. Many attacks occur in remote areas and go unreported. Even in areas where attacks are common, the overall incidence of bites is difficult to assess; people with fatal injuries are rarely brought to the hospital. Assessment of fatalities can be even more problematic. Without autopsy, determining whether injuries on a cadaver were the cause of death or were inflicted following death may be impossible.[32]

Animal behavior and crocodile attacks

An understanding of the motivation behind crocodile attacks on humans and the manner in which crocodiles attack humans allows better planning for treatment of injuries and preventive policy. Crocodilians are most likely to attack ''out of the blue,'' with a combination of ''stealth, surprise, and a sudden final burst of speed.''[49] In a number of series, victims report having no idea of the presence of an alligator or a crocodile before the attack. Crocodilians use a variety of methods to take large prey. When prey is at the water's edge, the crocodilian will typically lunge out the water at high speed and seize it with great force and considerable tenacity.[24,39] Once the prey is grabbed, it may be unbalanced and dragged back into the water. Here, the crocodilian may roll its body over and over—the rather dramatically named *death roll*—which subdues prey through disorientation and hypoxia and also assists in breaking it up into more manageable pieces. Crocodiles will also lunge at large prey swimming in the water, and the attack is more likely to be successful, because the prey is already unbalanced and has no footing on which to gain purchase and resist the crocodilian. A sideways snap may also be used to grab prey.

Pathology of crocodilian attacks

MORTALITY

In the only reported Australian series to date,[77] cause of death was attributed to either decapitation or truncal transection (Figure 2). It should be assumed that massive blood loss[90] and drowning are the cause of death in a large number of crocodilian attacks. Assessing the actual cause of death can be complicated by the fact that bodies are sometimes not found, have been eaten, or are decomposed to an extent that makes cause of death difficult to ascertain. Mercifully, death appears to be swift, with little or no bruising seen on postmortem examination. If the initial attack is survived, a further risk of death from sepsis exists. In the Malawian series of 60, there was 1 death from sepsis; the authors attribute their success to early aggressive surgery and broad-spectrum antibiotics.[78]

GROSS PATHOLOGY

The patterns of injuries inflicted by crocodilians occupy a wide spectrum in both nature and severity. The power and size of some animals are such that, if not lethal in the first instance, injuries can be as severe as those seen in major road trauma or in the military arena. Injury mechanisms are often a combination of penetrating, blunt, and shear forces, and this should be considered when evaluating wounds.

The most common injuries sustained in a crocodilian attack are serious soft tissue and bone injuries, most often of the extremities. Complex compound fractures and tissue loss are not uncommon in the more severe attacks. In the Malawian series, 40% of patients were left with permanent deformities, with the average patient undergoing 4 procedures during a 31-day hospital stay.[78] Crocodilian teeth are conical in shape and designed for penetration and holding,[8] so most wounds are initially deep punctures. The interdigitating teeth of crocodiles in particular can inflict slash wounds. Most attacks occur in the water or at the water's edge, and prolonged time underwater can result in drowning.

Although the most extensive injuries are frequently penetrating, consideration should be given to the added effect of the blunt force applied. This can devitalize large areas of tissue that surrounds penetrating injuries, rendering them even more susceptible to infection and delaying wound healing. Blunt injury can also be inflicted by the tail.

The anatomical area of the body affected by attacks appears to have a pattern of convenience—the animal will grasp whichever part of the person's anatomy is presented. In the largest series of injuries inflicted by

Nile crocodiles that describes sites of injury, legs and arms accounted for more than 80% of soft tissue injuries.[78] In the largest series of alligator-inflicted injuries,[32] this pattern of extremity injury is repeated, with 88% of injuries (where the site was described) affecting upper[91] and lower ($n = 75$) limbs. Wounds of the torso and head or neck accounted for 8.4%[16] and 4.2%,[8] respectively. Injuries to upper and lower limbs, including amputation, are well described elsewhere,[24,54,81,82,85,90] as are injuries to the chest,[77] head,[77,81] and groin.[83]

MICROBIOLOGICAL PATHOLOGY

In common with most carnivorous predators, bites from crocodilians must be assumed to be heavily soiled with a wide variety of bacteria. Compounding the problem of microbial load are the warm temperatures at which these wounds are inflicted, optimizing growth conditions. The first report[47] of oral flora of 2 captive alligators yielded *Clostridia*, enterococci, and *Citrobacter*, but these were not fully characterized. *Salmonella* has been reported in one series.[81] Further case reports describe the frequency of *Aeromonas hydrophila* infection following alligator bites.[86,87,92] One study of American alligators captured for the purpose of examining their oral flora also confirmed the presence of *A hydrophila* in 9 of the 10 alligators assayed.[84] It is not clear whether similar microbial fauna contaminate the oral cavities of antipodean crocodilians, because similar studies have never been completed. In the only reported Australian series, similar microorganisms were isolated from wounds, but it is possible that these were environmental contaminants.[77] Whether the microorganisms isolated were from infected bite sites or clean wounds was not documented. Of note in this series, *Burkholderia pseudomallei* was also isolated from the wound site and blood of one case, the only such transmission of infection by this microorganism ever reported. In general, delayed wound healing and recurrent infections are the norm with crocodile bites.

The most prevalent species identified in the mouth and cloaca of captive and wild *C porosus* and *C johnstoni* were *A hydrophila* and *Pseudomonas aeruginosa*, both found in 64% of crocodiles examined, followed by *Proteus vulgaris* (51%), *Proteus mirabilis* (38%), *Salmonella* spp. (36%), and *Proteus penneri* (33%).[93] Other gram-negative species identified included *Acinetobacter johnsonii*, *Bacillus* spp., *Budvicia aquatica*, and *Yersinia intermedia*.

The management of crocodilian injuries

Given the unusual nature of injuries sustained from crocodilian attacks, it is not surprising that the literature regarding their management is sparse. The management principles of crocodilian attacks can be compared with the management of shark attacks[94]; the same problems of potentially massive injuries, sustained in remote areas, with subsequent virulent wound infection occur. Some shark attacks happen in areas frequented by surfers and bathers and therefore patrolled by lifeguards. They in turn are in a position to provide basic, and in some cases advanced, life support interventions. Crocodilian attacks, however, almost always occur in areas well away from such basic interventions.

PREHOSPITAL

The prehospital management of injuries inflicted by crocodilians can affect not only survival from the attack but also long-term morbidity. Initial resuscitation must be directed toward securing an airway and circulation management. In the prehospital phase, the patient should be rapidly removed to a place of safety well away from the water before treatment is commenced. Following a period of prolonged submersion, basic airway maneuvers, the clearance of inhaled or aspirated detritus from the upper airway, and even mouth-to-mouth ventilation may be required. Penetrating chest wounds should be bandaged with simple occlusive dressings taped on 3 sides, particularly if there is an air leak, to mitigate against the possibility of tension pneumothorax. Once the airway and breathing have been secured, hemostasis should be sought. Hemorrhage from vascular structures, where visible, should be controlled through direct pressure and, if required, wound packing combined with elastic bandage dressing.[95] Although the use of tourniquets in the military environment has recently been reexamined,[96] the evidence does not exist to either support or refute their use in the civilian environment, and the potential hazards are well described.[95] Considerable bleeding can occur from long bone and pelvic fractures. Long bone fractures should be reduced and splinted, and the pelvis should be strapped should a major fracture be suspected. This will not only minimize bleeding but also facilitate the transportation of patients to a point of definitive care. Evacuation can be problematic, because contacting emergency services with standard communication devices is often impossible due to the remote location of the attack. Emergency personal beacons have been used to good effect in remote outback Australia.[97]

Prehospital care does not stop with addressing the airway, breathing, and circulation. Early methodical wound care, particularly (as is often the case with these injuries) if a delayed field extrication is anticipated, can help minimize later morbidity. Wounds should be irrigated with copious volumes of at least potable water—with soap or

disinfectant where available—and dressed with sterile dressings. The role of prehospital prophylactic antibiotics is unproven but may be considered if delay to extrication appears to be extending to days. Amoxicillin-clavulanate, azithromycin, and ciprofloxacin may all provide some protection from wound infection.

HOSPITAL

An attack by a fully grown crocodile or alligator usually results in serious injuries. Clinicians should be alert to the common pitfall of assuming that the most obvious and frequently massive injuries with which they are presented are the only ones present.

Once patients arrive in the hospital, unless they appear to have sustained minimal injuries and are cardiovascularly stable, management should be in the operating room. Plain radiographs should be taken of the injury sites to examine for fractures, periosteal stripping, or tooth fragments. Wounds associated with joints should be assumed to be intra-articular until local exploration proves otherwise. A strong argument can be advanced for obtaining a head computed tomographic scan on all patients who have sustained an injury to that region to rule out an intracranial injury. In remote hospitals where computed tomographic scanning is not available, there may still be some merit in obtaining skull radiographs.

All wounds should be considered heavily soiled and further compromised by the crushing forces generated by the bite, devitalizing tissue. In the hospital, exploration of all wounds should be encouraged, and surgical debridement of dead and threatened tissue should be undertaken in all patients. Topical antisepsis has been shown to be of some value in simple abrasions,[98] but in the deep puncture wounds generally created by crocodilians, their efficacy remains unproven.

The role of routine wound cultures and prophylactic antibiotics remains contentious. The routine culturing of wounds in general has limited value in predicting whether an infection will develop or not.[99] Some organisms that might be anticipated are fastidious, and a negative culture result might give a falsely reassuring result. Where there is a clinical suspicion of infection or in high-risk patients (such as those with diabetes), wound cultures might be of value. Similarly, there may be some role for simple quantitative culture of wound sites and debrided tissue. Wounds that have begun to show evidence of infection should be swabbed and sent for both aerobic and anaerobic culture. The microbiologists should be advised of the nature of the specimen in advance so that the appropriate selective media can be used. Prophylactic antibiotics have been recommended in certain high-risk situations for mammalian injuries,[100] and adopting at least these guidelines seems prudent. These situations include hand injuries, prolonged delays before definitive care, and crush injuries. The choice of antibiotics is at best empirical and will depend to a certain degree on local microbial flora. The authors of the Australian series recommend ceftazidime to cover the locally endemic *B pseudomallei* (and most *Aeromonas* spp.), penicillin for clostridial infections, and metronidazole for anaerobic infections.[77,79] Flucloxacillin or an equivalent might be considered for skin commensals. Antibiotic choice should be altered according to culture sensitivities. If there is uncertainty about tetanus status, 250 to 500 U of human tetanus immunoglobulin and 0.5 mL of diphtheria tetanus toxoid should be administered in separate arms.

Given the grossly contaminated nature of all of these wounds, secondary closure should be considered in all cases. More than half of the cases where clinical details are recorded report wound infections. Neurovascular injury should be identified, and a number of surgical specialties (orthopedics, vascular) may need to be involved early in the person's care. Both the surgeon and the patient should anticipate the need for multiple surgical procedures.

REHABILITATION

The devastating nature of attacks caused by crocodilians usually results in a prolonged and often difficult period of rehabilitation. Regular physiotherapy for several months following injuries, punctuated by return to surgery for further debridement, is not uncommon. The psychological impact of such an event should similarly not be underestimated, and posttraumatic stress disorder symptoms should be anticipated and addressed.[101] Management of the psychological impact of such large animal attacks is underreported and worthy of further study.

Prevention

The prevention of crocodile attacks can be considered as primary (avoiding an attack altogether) and secondary preventive techniques (minimizing the harm and complications after an attack has occurred). Primary prevention involves minimizing contact between humans and crocodilians. A wide variety of factors bring the 2 parties together, including the growing populations of both humans and crocodilians. In the developing world, circumstances can force humans into close proximity with crocodilians. In Tanzania in 1994, failure of the town water pump in the Korogwe district forced villagers to seek water from the crocodile-infested Pangani River, with a subsequent surge in crocodile-related injuries and

deaths.[92] Movement of refugees in Africa into lands with which they are unfamiliar and pressure to reclaim marshland to grow cash crops have also been blamed for human encroachment on crocodile territory. In the developed world, the increased interest in outdoor adventure sports and so-called eco-tourism brings more people into contact with crocodiles, reducing the latter's natural apprehension for their only other predator.

Crocodiles are also increasingly encroaching on human territory. Since protective legislation was introduced in Australia and the United States in the 1970s, the numbers of crocodiles and alligators, respectively, has increased sharply, and sophisticated management programs are in place.[102,103] The success in conservation has required the introduction of rational techniques in controlling populations and individual nuisance animals. In 1989, the Florida Fish and Wildlife Conservation Commission was receiving approximately 7000 nuisance alligator complaints per annum. In 2001, it received 16 749 complaints.[63] In the United States, trappers are typically employed to capture nuisance alligators, whereas in Australia, wildlife rangers are currently responsible for the capture and removal of problem saltwater crocodiles.[51,104–106]

As is the case with many pathologic entities, secondary preventive interventions in mitigating the consequences of a crocodilian attack are far less satisfactory than the methods outlined herein. The unanimous advice for defending oneself against an attack appears to be to fight back. Survivors in Malawi and Australia all attribute their successful escapes to vigorously resisting the attack. Gouging the crocodilian's eyes appears to be an effective action.[90] It has been suggested that if your hand is trapped in the mouth of the crocodile, reaching in to displace the palatal valve and cause the crocodile to aspirate water is effective. This has resulted in success in at least one case reviewed.[80]

A number of precautions can be taken to avoid adverse interactions with crocodiles.[39,68,91,107] If venturing into areas that may contain crocodiles, it is advisable to contact the local wildlife authorities beforehand for relevant information about crocodiles in the area. Warning signs posted near waterways should be heeded.[104] If camping near bodies of water that contain crocodiles, camp should be set up some distance from the water's edge, and individuals should be particularly careful about venturing near the water. Water should be collected from a different spot each time, and no food scraps (eg, fish carcasses) that may attract crocodiles should be left behind. Swimming or wading should be avoided.

The fact that crocodiles cannot be seen in a particular body of water does not mean that they are not there, and caution should always be exercised. Unfortunately, the effects of alcohol may affect people's behavior—at least 29% of the attacks in our series involved alcohol consumption.

Unless provoked, wild Australian freshwater crocodiles (*C johnstoni*) are generally considered harmless to humans and live in many areas visited by tourists and locals for recreational purposes. However, the long-term absence of saltwater crocodiles cannot always be guaranteed, even in habitats considered to be optimal for freshwater crocodiles.[108] For example, an intensive capture program for freshwater crocodiles in the McKinlay River area (Northern Territory) in 1978 to 1988 revealed no saltwater crocodiles in the river system. In 2001 to 2002, when the catch program was reinitiated, saltwater crocodiles (<4 m long) were recorded in various billabongs. Movement of saltwater crocodiles into these upstream habitats typically occurs during the wet season, when the isolated, dry season billabongs are joined as one waterway.

Conclusions

Crocodilians are opportunistic predators that are most dangerous in water and at the water-land interface,[8] as confirmed by analysis of attacks by saltwater crocodiles, Nile crocodiles, and American alligators. Because of its highly territorial nature,[54] the saltwater crocodile is often described as the most dangerous of all crocodilians. Notwithstanding incomplete reporting of attacks, the Nile crocodile is responsible for more human fatalities than other crocodilians because of its wide distribution in Africa[5] and the reliance by local communities on the same waterways inhabited by the species.

In northern Australia, the incidence of saltwater crocodile attacks has increased in recent years in part because of increasing populations of crocodiles in each state or territory.[51,105,109] This situation is also apparent in other parts of the world, where successful conservation and management measures are leading to the recovery of crocodilian populations. Increases in human populations, development of habitat, and the increased popularity of water-based recreational activities are also cited as factors that lead to increased human-crocodilian interactions. When crocodilian populations are small and perhaps endangered, the community's view is generally positive toward their conservation and population recovery. However, once population recovery becomes apparent, the community's view may reverse, particularly if interactions between people (and livestock) increase and recreational activities such as swimming are restricted. At the 13th Conference of the Parties to CITES, a number of countries raised concerns regarding possible

loss of community support in the face of increasing crocodilian populations.[110]

Loss of community support has been recognized by the Crocodile Specialist Group of the Species Survival Commission of the IUCN-World Conservation Union, which established a Human-Crocodile Conflict Working Group in 2002. The aims of the Human-Crocodile Conflict Working Group are to develop guidelines on the prevention and management of human-crocodile conflicts for wildlife authorities, to develop a database on crocodile attacks based on formal reporting, and to develop a fact sheet that combines information from the guidelines and database to assist developing countries.[111]

Outside the United States and Australia, detailed statistics on attacks are less reliable. Even in Australia, a more formal reporting format that attempts to link medical information to the circumstances and details of attacks would be useful. A crocodilian attack registry, similar to the International Shark Attack File, could provide invaluable herpetologic, ecologic, and clinical data regarding the best options for wound care, antibiotic choice, and other problems. Further studies are needed to elucidate the nature of the oral flora of Australian crocodiles, as have been completed for American alligators. Studies are also required to further delineate the likely organisms associated with crocodilian bite infections.

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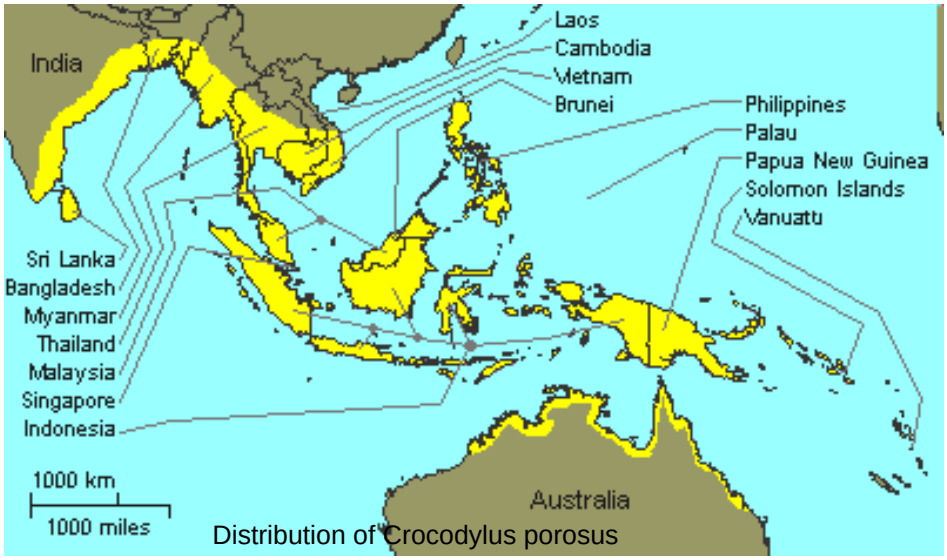
References

1. Graham A. *Eyelids of Morning: The Mingled Destinies of Crocodiles and Men.* San Francisco, CA: Chronicle Books; 1990.
2. King FW, Burke RL. *Crocodilian, Tuatara and Turtles Species of the World: A Taxonomic and Geographic Reference.* Washington, DC: Association Systematics Collections; 1989.
3. Bellairs Ad'A. The Crocodilia. In: Webb GJW, Manolis SC, Whitehead PJ, eds. *Wildlife Management: Crocodiles and Alligators.* Chipping Norton, Australia: Surrey Beatty & Sons; 1987:5–7.
4. Dodson P. Allure of El Lagarto: why do dinosaur paleontologists love alligators, crocodiles, and their kin? *Anat Rec A Discov Mol Cell Evol Biol.* 2003;274:887–890.
5. Ross JP, ed. *Crocodiles: Status Survey and Conservation Action Plan.* Gland, Switzerland: IUCN; 1998.
6. Davidson I, Solomon S. Was OH7 the victim of a crocodile attack? *Tempus.* 1990;2:197–206.
7. Reed AW. Crocodile people. In: *Aboriginal Myths and Legends.* Sydney, Australia: Reed New Holland; 1999: 211–228.
8. Webb G, Manolis C. *Australian Crocodiles.* Sydney, Australia: Reed New Holland; 1998.
9. Lanhupuy W. Aboriginal attitudes to crocodile management. In: Webb GJW, Manolis SC, Whitehead PJ, eds. *Wildlife Management: Crocodiles and Alligators.* Chipping Norton, Australia: Surrey Beatty & Sons; 1987:145–147.
10. Ritchie J, Jong J. *Bujang Senang Terror of Batang Lupar.* Kuching, Malaysia: Samasa Press; 1993.
11. Steubing R. Sarawak's killer crocodiles. *Malayan Naturalist.* 1983;37:17–23.
12. Daltry JC, Chheang D, Em P, et al. *Status of the Siamese Crocodile in the Central Cardamom Mountains, Southwest Cambodia.* Cambodian Crocodile Phnom Penh: Conservation Programme, Fauna and Flora International, Cambodia Programme and Department of Forestry and Wildlife; 2003.
13. Morenz LD. Die Sobeks - Spuren von Volksreligion im ägyptischen Mittleren Reich [The Sobeks–Traces of popular religion in the Egyptian Middle Kingdom]. *IBAES IV Conference Proceedings.* 2002; Berlin, Germany. Tierkulte im pharaonischen Ägypten, 83–97. Available at: www2.rz.hu-berlin.de/nilus/net_publications/ibaes4/morenz/text.pdf.
14. Seawright C. Sobek, God of crocodiles, power, protection and fertility. Available at: http://www.thekeep.org/kunoichi/kunoichi/themestream/sobek.html. Accessed 2002.
15. Trompf GW. Mythology, religion, art, and literature. In: *Crocodiles and Alligators.* New York, NY: Weldon Owen; 1989:156–171.
16. Le Moyne J. Indorum Floridam proviniciam inhabitantium elcones. In: Byr T. *Voyages en Virginie et eu Floride.* Paris, France: Ducharte et Van Buggenhoudt; 1926.
17. Jelden D. Crocodilians within CITES. *Crocodiles: Proceedings of the 17th Working Meeting of the IUCN-SSC Crocodile Specialist Group.* May 24–29, 2004; Darwin, NT, Australia. Gland, Switzerland: IUCN; 2004:69–71.
18. Hutton J, Webb GJW. Crocodiles: legal trade snaps back. In: Oldfield S, ed. *Trade in Wildlife: Regulation for Conservation.* London, England: Earthscan Publications; 2003:108–120.
19. Evans P, Wilkinson P. Black caiman attack. *Crocodile Specialist Group Newsletter.* 1997;16(3):5–6.
20. Hall PM. Dangerous to man? A record of an attack by a black caiman in Guyana. *Herp Rev.* 1991;22:9–11.
21. Marlin JA, Marlin KK, Platt SG. A documented case of an attack by Morelet's crocodile (*Crocodylus moreletii*) on man. *Bull Chicago Herp Soc.* 1995;30:165–167.
22. Finger AG, Rainwater TR, McMurry ST, Platt SG, Rosado N, Windsor M, Mazzotti FJ. Human-crocodile conflict in Belize: a summary. *Crocodiles: Proceedings of*

the 16th Working Meeting of the IUCN-SSC Crocodile Specialist Group. October 7–10, 2002; Gainesville, FL. Gland, Switzerland: IUCN; 2002:198–199.
23. Huerta-Ortega SM, Ponce-Campos P. Interacción hombre-cocodrilo en la costa de Jalisco, México. *Crocodiles: Proceedings of the 16th Working Meeting of the IUCN-SSC Crocodile Specialist Group.* October 7–10, 2002; Gainesville, FL. Gland, Switzerland: IUCN; 2002:200–203.
24. Guggisberg CAW. *Crocodiles: Their Natural History, Folklore and Conservation.* Mt Eliza, Victoria: Wren Publishing; 1972.
25. Vyas R. Recent cases of man-eating by the mugger (*Crocodylus palustris*) in Gujarat State. *Hamadryad (Madras).* 1993;18:48–49.
26. Bustard HR, Singh LAK. Gharial attacks on man. *J Bombay Nat Hist Soc.* 1982;78:610–611.
27. Lindner G. Crocodile management: Kakadu National Park. *Crocodiles: Proceedings of the 17th Working Meeting of the IUCN-SSC Crocodile Specialist Group.* May 24–29, 2004; Darwin, NT, Australia. Gland, Switzerland: IUCN; 2004:41–51.
28. Carle W. Alligators DO attack! *Florida Wildlife.* 1948; 2(4):10–11.
29. Neill WT. *The Last of the Ruling Reptiles: Alligators, Crocodiles and Their Kin.* New York, NY: Columbia University Press; 1971.
30. McIlhenny EA. *The Alligator's Life History.* Athens, Ohio: Society for the Study of Amphibians and Reptiles; 1976.
31. Hines TC, Keenlyne KD. Alligator attacks on humans in Florida. *Proceedings of the 30th Annual Conference Southeastern Association of Fish and Wildlife Agencies.* 1976;30:358–361.
32. Conover MR, Dubow TJ. Alligator attacks on humans in the United States. *Herp Rev.* 1997;28:120–124.
33. Wright B. *Wildlife Sketches Near and Far.* Fredrickton, New Brunswick: University of New Brunswick Press; 1962.
34. Platt SG, Ko WK, Kalyar Myo M, Khaing LL, Rainwater T. Man eating by estuarine crocodiles: the Ramree Island massacre revisited. *Herp Bull.* 2001;75:15–18.
35. Iordansky NN. The skull of the Crocodilia. In: Gans C, ed. *Biology of the Reptilia.* Vol 4. New York, NY: Academic Press; 1973:201–262.
36. Richardson KR, Webb GJW, Manolis SC. *Crocodiles: Inside and Out.* Chipping Norton, Australia: Surrey Beatty & Sons; 2002.
37. Erickson GM, Lappin AK, Vliet KA. The ontogeny of bite-force performance in American alligator (*Alligator mississippiensis*). *J Zool (Lond).* 2003;260:317–327.
38. Cox D. Alligator's bite could lift a small truck. Science Daily 29/3/2002. Available at: www.sciencedaily.com/releases/2002/03/020328073614.html.
39. Grenard S. *Handbook of Alligators and Crocodiles.* Malabar, FL: Krieger Publishing Co; 1991.
40. Webb GJW, Gans C. Galloping in *Crocodylus johnstoni*: a reflection of terrestrial activity? *Rec Aust Mus.* 1982; 34:607–618.
41. Webb GJW, Messel H, Crawford J, Yerbury M. Growth rates of *Crocodylus porosus* (Reptilia: Crocodilia) from Arnhem Land, northern Australia. *Aust Wildlife Res.* 1978;5:385–399.
42. Groombridge B. The distribution and status of world crocodilians. In: Webb GJW, Manolis SC, Whitehead PJ, eds. *Wildlife Management: Crocodiles and Alligators.* Chipping Norton, Australia: Surrey Beatty & Sons; 1987: 9–21.
43. Joanen T, McNease L. The management of alligators in Louisiana, USA. In: Webb GJW, Manolis SC, Whitehead PJ, eds. *Wildlife Management: Crocodiles and Alligators.* Chipping Norton, Australia: Surrey Beatty & Sons; 1987: 33–42.
44. Bellairs Ad'A. The senses of crocodilians. *Crocodiles: Proceedings of the First Working Meeting of the IUCN-SSC Crocodile Specialist Group.* March 15–17, 1971; New York. Gland, Switzerland: IUCN; 1971:181–190.
45. Soares D. Extinct crocodiles had specialized sensory organs to detect water surface disruptions. *Crocodiles: Proceedings of the 16th Working Meeting of the IUCN-SSC Crocodile Specialist Group.* October 7–10, 2002; Gainesville, FL. Gland, Switzerland: IUCN; 2002:131.
46. White FN. Redistribution of cardiac output in the diving alligator. *Copeia.* 1969;1969(3):567–570.
47. Webb GJW. Comparative cardiac anatomy of the Reptilia, III: the heart of *Crocodylus porosus* with notes on the complete interventricular septum of crocodiles and birds. *J Morph.* 1979;161:221–240.
48. Deepthi S, Johnson A, Sathish R, Pattabhi V. Purification, crystallisation and preliminary x-ray study of haemoglobin from *Crocodylus palustris* and *Crocodylus porosus*. *Biochim Biophys Acta.* 2000;1480:384–387.
49. Cott HB. Scientific results of an enquiry into the ecology and economic status of the Nile crocodile (*Crocodylus niloticus*) in Uganda and northern Rhodesia. *Trans Zool Soc Lond.* 1961;29:211–357.
50. Webb GJW, Manolis SC, Whitehead PJ, Letts GA. *A Proposal for the Transfer of the Australian Population of* Crocodylus porosus *Schneider (1801), from Appendix I to Appendix II of C.I.T.E.S.* Technical Report 21. Darwin, Australia: Conservation Commission of the Northern Territory; 1984.
51. Webb GJW, Britton ARC, Manolis SC, Ottley B, Stirrat S. The recovery of *Crocodylus porosus* in the Northern Territory of Australia: 1971–1998. *Crocodiles: Proceedings of the 15th Working Meeting of the IUCN-SSC Crocodile Specialist Group.* January 17–20, 2000; Varadero, Cuba. Gland, Switzerland: IUCN; 2000:196–235.
52. Andau P, Ambu L, Tsubouchi T. Indication of crocodile recovery and management implications in crocodile conservation in Sabah. *Crocodiles: Proceedings of the 17th Working Meeting of the IUCN-SSC Crocodile Specialist Group.* May 24–29, 2004; Darwin, NT, Australia. Gland, Switzerland: IUCN; 2004:204–207.

53. Glasgow VL. *A Social History of the American Alligator.* New York, NY: St Martins Press; 1991.
54. Lang JW. Crocodilian behaviour: implications for management. In: Webb GJW, Manolis SC, Whitehead PJ, eds. *Wildlife Management: Crocodiles and Alligators.* Chipping Norton, Australia: Surrey Beatty & Sons; 1987:273–294.
55. Kay W, Fitzsimmons N, Grigg G. Movements of *Crocodylus porosus* in the Kimberley region of Western Australia: integrating genetic and radio-tracking data. *Crocodiles: Proceedings of the 17th Working Meeting of the IUCN-SSC Crocodile Specialist Group.* May 24–29, 2004; Darwin, NT, Australia. Gland, Switzerland: IUCN; 2004:385.
56. Read M, Grigg G, Franklin C, Irwin S. Movements of adult-sized estuarine crocodiles (*Crocodylus porosus*) tracked by satellite telemetry. *Crocodiles: Proceedings of the 17th Working Meeting of the IUCN-SSC Crocodile Specialist Group.* May 24–29, 2004; Darwin, NT, Australia. Gland, Switzerland: IUCN; 2004:386.
57. Lang JW. Social behaviour. In: *Crocodiles and Alligators.* New York, NY: Weldon Owen; 1989:102–117.
58. Britton ARC. Review and classification of call types of juvenile crocodilians, and factors affecting distress calls. In: Grigg GC, Seebacher F, Franklin CE, eds. *Crocodilian Biology and Evolution.* Chipping Norton, Australia: Surrey Beatty & Sons; 2001:364–377.
59. Webb GJW, Manolis SC, Buckworth R. *Crocodylus johnstoni* in the McKinlay River area, N.T. I: variation in the diet and a new method of assessing the relative importance of prey. *Aust J Zool.* 1982;30:877–899.
60. Mawson P. Crocodile management in Western Australia. *Crocodiles: Proceedings of the 17th Working Meeting of the IUCN-SSC Crocodile Specialist Group.* May 24–29, 2004; Darwin, NT, Australia. Gland, Switzerland: IUCN; 2004:28–37.
61. Fergusson R. Preliminary analysis of data in the African human-crocodile conflict database. *Crocodile Specialist Group Newsletter.* 2004;24(4):21–22.
62. Stringer C. *The Saga of Sweetheart.* Darwin, Australia: Adventure Publications; 1986.
63. Lyons ARC. *Are Interactive Crocodile Tours on the Adelaide River Leading to Measurable Changes in Saltwater Crocodile (*Crocodylus porosus*) Behaviour?* Darwin, Australia: Northern Territory University; 1999.
64. Webb GJW, Yerbury M, Onions V. A record of a *Crocodylus porosus* (Reptilia, Crocodylidae) attack. *J Herpetol.* 1978;12:267–268.
65. Steubing R. Sarawak's killer crocodiles. *Malayan Naturalist.* 1983;37:17–23.
66. Steubing R, Ismael G, Sallih K. *On the Possible Causes of Crocodile Attacks in Batang Lupar, Sarawak.* Kota Kinabalu: University of Malaysia Sabah Campus; 1985.
67. Richardson J, Livingstone D. An attack by a Nile crocodile on a small boat. *Copeia.* 1962;1962(1):203–204.
68. Pooley AC, Hines T, Shields J. Attacks on humans. In: *Crocodiles and Alligators.* New York, NY: Weldon Owen; 1989:172–186.
69. Edwards H. *Crocodile Attack in Australia.* Marleston, Australia: JB Books; 1998.
70. Webb GJW, Whitehead PJ, Manolis SC. Crocodile management in the Northern Territory of Australia. In: Webb GJW, Manolis SC, Whitehead PJ, eds. *Wildlife Management: Crocodiles and Alligators.* Chipping Norton, Australia: Surrey Beatty and Sons; 1987:107–124.
71. Webb GJW, Messel H. Morphometric analysis of *Crocodylus porosus* from the north coast of Arnhem Land, northern Australia. *Aust J Zool.* 1978;26:1–27.
72. Lading E. Crocodile conservation in Sarawak. *Crocodiles: Proceedings of the 17th Working Meeting of the IUCN-SSC Crocodile Specialist Group.* May 24–29, 2004; Darwin, NT, Australia. Gland, Switzerland: IUCN; 2004:174–179.
73. Republic of Namibia. *Transfer of the Namibian Population of Nile Crocodile (*Crocodylus niloticus*) to Appendix II.* CITES COP13 Proposal No. 25. Geneva, Switzerland: CITES; October 2004.
74. Republic of Zambia. *Maintenance of the Zambian population of* Crocodylus niloticus *on Appendix II, Subject to an Annual Export Quota of No More Than 548 Wild Specimens (Including Hunting Trophies and Problem Animal Control).* CITES COP13 Proposal No. 26. Geneva, Switzerland: CITES; October 2004.
75. Burgess GH, Callahan MT, Howard RJ. Sharks, alligators, barracudas, and other biting animals in Florida waters. *J Fla Med Assoc.* 1997;84:428–432.
76. Sabah Wildlife Department. *Crocodile Management in Sabah.* Kota Kinabalu, Malaysia: Sabah Wildlife Department; 1992.
77. Mekisic AP, Wardill JR. Crocodile attacks in the Northern Territory of Australia. *Med J Aust.* 1992;157:751–754.
78. Vanwersch K. Crocodile bite injury in southern Malawi. *Trop Doct.* 1998;28:221–222.
79. Tuakli J, Wosornu L. Animal bites and injuries: indications for metronidazole. *Med J Zambia.* 1979;13:54–57.
80. Doering EJ III, Fitts CT, Rambo WM, Bradham GB. Alligator bite. *JAMA.* 1971;218:255–256.
81. Raynor AC, Bingham HG, Caffee HH, Dell P. Alligator bites and related infections. *J Fla Med Assoc.* 1983;70:107–110.
82. Hakansson BO. A wonderful dog-master story. *Trop Doct.* 1996;26:88.
83. Katlowitz NM, Fliescher A, Benet AE. Reestablishment of male sexual function and appearance 23 years after alligator induced traumatic orchiectomy and penile lacerations. *J Urol.* 1995;153:1929–1930.
84. Flandry F, Lisecki EJ, Domingue GJ, Nichols RL, Greer DL, Haddad RJ Jr. Initial antibiotic therapy for alligator bites: characterization of the oral flora of *Alligator mississippiensis*. *South Med J.* 1989;82:262–266.
85. Hines TC, Keenlyne KD. Two incidents of alligator at-

tacks on humans in Florida. *Copeia.* 1977;1977(4):735–738.
86. Spillan T. Gator bite. *Fla Wildlife.* July 1983:41–42.
87. Rosenthal SG, Bernhardt HE, Phillips JA III. *Aeromonas hydrophila* wound infection. *Plast Reconstr Surg.* 1974; 53:77.
88. Behra O. Reports of crocodiles attacks on people in Madagascar 1990 to 1996. *Crocodile Specialist Group Newsletter.* 1996;15(3):3–4.
89. Kar SK, Bustard HK. Saltwater crocodile attacks on man. *Biol Cons.* 1983;25:377–382.
90. Pooley T. *Discoveries of a Crocodile Man.* London, England: William Collins Sons & Co Ltd; 1982.
91. Holden P. *Crocodile: The Australian Story.* Sydney, Australia: Hodder & Stoughton; 1993.
92. Scott R, Scott H. Crocodile bites and traditional beliefs in Korogwe District, Tanzania. *BMJ.* 1994;309:1691–1692.
93. Anderson JR. Characterisation of the oral and cloacal flora of wild and farmed crocodiles (*Crocodylus porosus* and *C. johnstoni*) in northern Australia [Honour's thesis]. Townsville: James Cook University of North Queensland; 1999.
94. Caldicott DG, Mahajani R, Kuhn M. The anatomy of a shark attack: a case report and review of the literature. *Injury.* 2001;32:445–453.
95. Husum H, Gilbert M, Wisborg T, Pillgram-Larsen J. Prehospital tourniquets: there should be no controversy. *J Trauma.* 2004;56:214–215.
96. Navein J, Coupland R, Dunn R. The tourniquet controversy. *J Trauma.* 2003;54:S219–S220.
97. Meade K. Mates wrestle man-eating crocodile to rescue attack victim. *The Australian.* August 1999:3.
98. Geronemus RG, Mertz PM, Eaglstein WH. Wound healing: the effects of topical antimicrobial agents. *Arch Dermatol.* 1979;115:1311–1314.
99. Fleisher GR. The management of bite wounds. *N Engl J Med.* 1999;340:138–140.
100. Freer L. North American wild mammalian injuries. *Emerg Med Clin North Am.* 2004;22:445–473.
101. Denholm CJ. Survival from a wild animal attack: a case study analysis of adolescent coping. *Matern Child Nurs J.* 1995;23:26–34.
102. Read M, Wright B, Enoch C. Crocodile management in Queensland: an overview. *Crocodiles: Proceedings of the 17th Working Meeting of the IUCN-SSC Crocodile Specialist Group.* May 24–29, 2004; Darwin, NT, Australia. Gland, Switzerland: IUCN; 2004:13–27.
103. Hoffman E. Australia's saltwater crocodile: a threat or a promise? *Pacific Discovery.* 1987;40:6–17.
104. Letnic M. Crocodile management in the Northern Territory of Australia. *Crocodiles: Proceedings of the 17th Working Meeting of the IUCN-SSC Crocodile Specialist Group.* May 24–29, 2004; Darwin, NT, Australia. Gland, Switzerland: IUCN; 2004:4–12.
105. Elsey R, Kinler N. Louisiana's alligator program: adapting management as populations recover and risk of unsustainable use decreases. *Crocodiles: Proceedings of the 17th Working Meeting of the IUCN-SSC Crocodile Specialist Group.* May 24–29, 2004; Darwin, NT, Australia. Gland, Switzerland: IUCN; 2004:92–101.
106. Dutton HJ, Brunell AM, Carbonneau DA, et al. Florida's alligator management program: an update 1987 to 2001. *Crocodiles: Proceedings of the 16th Working Meeting of the IUCN-SSC Crocodile Specialist Group.* October 7–10, 2002; Gainesville, FL. Gland, Switzerland: IUCN; 2002:23–30.
107. Pooley AC. Safety precautions for visitors to crocodilian areas. In: *Crocodiles and Alligators.* New York, NY: Weldon Owen; 1989:187.
108. Butler WH. Living with crocodiles in the Northern Territory of Australia. In: Webb GJW, Manolis SC, Whitehead PJ, eds. *Wildlife Management: Crocodiles and Alligators.* Chipping Norton, Australia: Surrey Beatty & Sons; 1987:229–231.
109. Read MA, Miller JD, Bell IP, Felton A. The distribution and abundance of the estuarine crocodile, *Crocodylus porosus*, in Queensland. *Wildlife Res.* 2004;31:527–534.
110. Manolis C. CITES COP13. *Crocodile Specialist Group Newsletter.* 2004;23(4):3.
111. Fergusson R. Report of the Human-Crocodile Conflict Workshop. *Crocodiles: Proceedings of the 17th Working Meeting of the IUCN-SSC Crocodile Specialist Group.* May 24–29, 2004; Darwin, NT, Australia. Gland, Switzerland: IUCN; 2004:525.



Distribution of Crocodylus porosus

Australia, Bangladesh, Brunei, Burma, Cambodia, China, India (including Andaman Islands), Indonesia, Malaysia, Palau Papua New Guinea, Philippines, Singapore, Sri Lanka, Solomon Islands, Thailand, Vanuatu (Banks Islands), Vietnam.