

CROCODILE SPECIALIST GROUP NEWSLETTER

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NEWSLETTER

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JULY 2026 - SEPTEMBER 2026

IUCN Species Survival Commission

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Cover: Stand-off between an Agile wallaby (*Macropus agilis*) and a Saltwater crocodile (*Crocodylus porosus*) on the Ord River, Western Australia. Photograph: Rodney Fischer.

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CSG Newsletter

The CSG Newsletter is produced and distributed by the Crocodile Specialist Group of the Species Survival Commission (SSC) of the IUCN (International Union for Conservation of Nature). The CSG Newsletter provides information on the conservation, status, news and current events concerning crocodilians, and on the activities of the CSG. It is available as a free electronic, downloadable copy from <http://www.iucnscg.org/pages/Publications.html>

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Editorial

In early September, we received a communication from the Secretariat of the Pacific Regional Environment Programme (SPREP), seeking quotations from suitably qualified experts to draft a CITES amendment proposal for the Saltwater crocodile (*Crocodylus porosus*) population in the Solomon Islands. The documentation provided was disseminated to the Steering Committee. Like other range states, the recovery of the *C. porosus* population in the Solomon Islands has led to a high frequency of attacks on people, and a CITES Appendix-II listing is considered to provide more options for management of the species.

We also received a request from the Colombian Ministry of Environment and Sustainable Development, to review and comment on the document entitled “Management of the Contingency Involving Orinoco Crocodile (*Crocodylus intermedius*) Specimens under Human Care, Formulation of the Release Plan, and Update of the National Program for the Conservation of the Orinoco Crocodile”. A small working group comprising CSG members with expertise with the species and/or reintroduction programs, was established to provide a response. At the time of writing, the working group was still working through the document.

On 10-11 September 2026, a [National Inception Workshop](#) to fine tune a National Action Plan for the Government of India Ministry of Environment and Forest’s [Project Gharial](#) (launched in October 2025). A number of CSG members with experience with Gharial, Muggers and/or Saltwater crocodiles joined forest officials, researchers, conservation practitioners and NGO representatives from India and Nepal at the workshop. We look forward to seeing the draft Action Plan associated with this important initiative in due course.

Good progress is being made with development of the new CSG website, and it is due to be launched before the end of the year. Many thanks to everyone who has contributed photographs and other material to the process.

Further to the Steering Committee meeting in Morocco (12 May 2026), an internal review of the CSG SRAS/FHVS-SRAS programs was undertaken. The SRAS program has been in place since 2009 (17 years) and the last review was carried out in 2018 by the Future Leaders Working Group. This latest review documented the changes that have been implemented since 2023, when Sally Isberg took on the role of Executive Officer. Overall, the programs is working well, in part due to the EO taking an adaptive management approach to SRAS processes, with actions being implemented if/when

issues are identified. The changes implemented over the last 2-3 years have reduced the amount of time expended by the EO at different stages of the application, review and reporting processes.

The latest International Alligator and Crocodile Trade Study (IACTS) report, compiled by John Caldwell and covering the 2022-2024 period, is now available on the [CSG website](#). Global trade between 2015 and 2024 has fluctuated between just over one million skins in 2020, during the global pandemic, to over 1.8 million skins in 2022.

There is little doubt that crocodilians have preyed upon humans and their ancestors throughout their evolutionary history of 6-7 million years. Interestingly, [Bertullo \(2015\)](#), covering the history of Traumatic Brain Injury (TBI), cites early works indicating that the first clinical evidence of brain injury (cranial fractures) in human evolution (*Homo habilis*) was discovered in prehistoric Tanzania, dating back approximately 1.8-2 million years BC, and apparently due to a crocodile bite.

A recent publication by [Flores et al. \(2026\)](#) examines the body temperature of *Tyrannosaurus rex*, as derived from clumped isotopes in enamel of fossil teeth. The authors derived an average temperature of 36.3°C for *T. rex* compared to 30.9°C for crocodilians. The results add important insights into a growing body of evidence for endothermy in theropod dinosaurs (see also [Seymour et al. 2026](#)).

Alejandro Larriera and Charlie Manolis, *CSG Co-Chairs*.

CSG Student Research Assistance Scheme

The Student Research Assistance Scheme (SRAS) and Fritz Huchzermeyer Veterinary Science Student Research Assistance Scheme (FHVS-SRAS) provided funding to four students in the July-September 2026 quarter (see below).

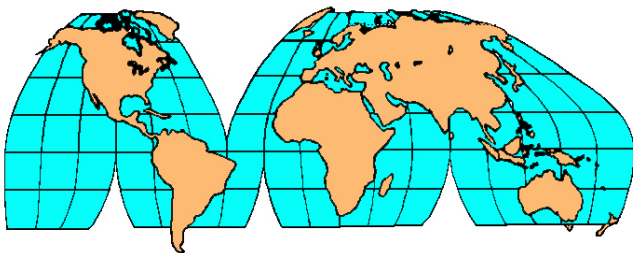
1. Gareth Hunter (South Africa; Project 26/7): The effect of lead on the health of Nile crocodiles (*Crocodylus niloticus*).
2. Edison Bonilla-Liberato (USA; 26/8): Developing UAV-based and deep-learning approaches for American alligator monitoring in the Greater Everglades.
3. Monif Horsham (Jamaica; 26/9): Influence of incubation method and diet on hatching success and hatchling growth in *Crocodylus acutus* from Holland Bay Crocodile Sanctuary in Jamaica.
4. Giovany Arturo González Desales (Mexico; 26/10): Ultrasonographic characterization and hormonal profile of follicular development of *Crocodylus acutus* and *Crocodylus moreletii* under professional care in Mexico.

The following SRAS reports were submitted in August-September 2026, and have been posted on the CSG website:

1. Gabriela M. Gama (Brazil; 20/13): Linking habitat protection, local communities livelihoods, and conservation of caimans in Brazilian Northeast Atlantic Forest. [Download](#).
2. Sigifredi Clavijo-Garzon (Colombia; 20/16): Genetic population ecology of *Caiman crocodilus fuscus* in the Prado River Hydroelectric Dam (HIDROPRADO): In search of the hybrid. [Download](#).
3. Javier Arturo Benítez Moreno (Guatemala; 22/9): Nesting ecology of American crocodile (*Crocodylus acutus*) in a natural private reserve in the Izabal Lake, Guatemala. [Download](#).
4. Tyler Hunt (USA; 23/1): Insights into the eco-sensory significance of crocodylian cranial morphology as revealed by visual field analysis. [Download](#).
5. David Andrade Domínguez (Ecuador; 24/13): Phylogenetic position, divergence time and climatic niche differentiation of *Crocodylus acutus* in Ecuador-Peru. [Download](#).

Dr. Sally Isberg, CSG Executive Officer (csg@wmi.com.au).

Regional Reports



North America

USA

SCALES OF SUCCESS: CELEBRATING THE AMERICAN ALLIGATOR AS A GLOBAL MODEL FOR CONSERVATION THROUGH SUSTAINABLE USE. On 21 July 2026, the U.S. Department of the Interior hosted “Scales of Success: The Triumph of the American Alligator”, an official Great American Expeditions and Freedom 250 event, in Washington, D.C. The program celebrated the remarkable recovery of the American alligator (*Alligator mississippiensis*) and the partnerships that transformed a species once in serious decline into one of the world’s most recognized examples of conservation through sustainable use.

The event brought together senior leadership from the U.S. Department of the Interior (DOI) and U.S. Fish and Wildlife Service (USFWS), state wildlife agencies, the CSG, conservation organizations, scientists, private landowners, alligator farmers and ranchers, hunters, tanneries, manufacturers, and representatives of the international luxury

industry and International Crocodilian Farmers Association (ICFA).

The documentary at the centre of the program, “Scales of Success: The Triumph of the American Alligator”, was produced and funded through a partnership among the Origins Foundation, Louisiana Alligator Advisory Council and Louisiana Alligator Farmers and Ranchers Association, with Samuel Rivera Films. It chronicles how wildlife agencies, scientists, landowners, farmers, hunters, conservationists, and the leather industry worked together over decades to restore the American alligator and create a management system capable of supporting both conservation and sustainable use.

The significance of the American alligator recovery was underscored by the participation of senior U.S. Government leadership from both DOI and USFWS. USFWS Director Brian Nesvik highlighted the importance of the partnerships underlying the recovery: “Conservation works best when it’s rooted in sound science, strong partnerships and local stewardship.”

Today, more than five million American alligators are estimated to occur across the southeastern United States. The recovery represents not simply a numerical increase in abundance, but the development of an enduring conservation system connecting wildlife management, habitat, regulated harvest, private land stewardship, farming and ranching, international trade, and economic incentives.

Louisiana Department of Wildlife and Fisheries Secretary Tyler Bosworth also participated in the program and announced a proclamation from Louisiana Governor Jeff Landry declaring 21 July 2026 “Louisiana’s Great American Alligator Day.” The proclamation recognized the contributions of wildlife professionals, private landowners, licensed alligator farmers, trappers, and the leather industry to the state’s conservation achievement. “Our Louisiana alligator management program is recognized internationally as a model for sustainable use,” Bosworth said.

The CSG was strongly represented throughout the event, reflecting the longstanding involvement of CSG members in crocodilian research, management, conservation, sustainable use, and trade. The film was narrated by Trey Gilmore, while CSG Industry Chair Christy Gilmore participated in the program as a speaker and panelist. Jonathan Warner and Matthew Nichols also served as panelists, contributing their expertise in alligator conservation, management, and sustainable use. CSG Deputy Chair Christine Lippai also attended the event, along with Jeff Donald, Savannah Boan, Nathan Wall, Joe Wasilewski and Morgan Hart. Their participation reflected both the breadth of expertise within the CSG and the important role its members have played in developing, implementing, and communicating science-based approaches to crocodilian conservation.

A central theme throughout the event was the importance of CITES and traceability to the American alligator conservation model. In her remarks, Christy Gilmore

highlighted the development of the universal CITES tagging system as a pivotal point in the history of American alligator conservation. The system established a mechanism through which legally harvested skins could be individually identified and traced through international commerce. This helped distinguish legal trade from illegal trade, gave governments and international buyers confidence in the legitimacy of the supply chain, and reduced the commercial opportunity for illegally harvested skins.



Figure 1. Christy Gilmore presents at the event.

During the panel discussion, the CITES tagging system was described as the “single most important factor” behind the species’ turnaround because effective traceability helped eliminate illegal trade while creating confidence that American alligator skins entering international commerce were legally acquired. The result was an important connection between trade and conservation. Legal, traceable commerce allowed



Figure 2. Panel discussion: from left, Sue Kerver (USFWS, moderator), Christy Gilmore, Mark Hoffberg (USFWS International Affairs), Matthew Nichols (alligator biologist, Florida Fish and Wildlife Conservation Commission), Jonathan Warner (alligator biologist, Texas Parks and Wildlife Department).

landowners, farmers, ranchers, hunters, manufacturers, and other participants in the supply chain to derive economic value from healthy alligator populations while giving governments the ability to regulate and monitor that trade.

The event also addressed a sometimes overlooked component of the American alligator story: the role of markets in creating incentives for conservation. For decades, international demand for legally sourced American alligator leather has helped give alligators and the wetlands supporting them tangible economic value. That value has provided incentives for private landowners to maintain habitat, supported licensed farming and ranching programs, sustained rural economies, and contributed to a highly regulated and transparent wildlife trade system.

The message presented in Washington was that the American alligator did not recover despite a commercial market for its leather; a well-regulated and traceable market became part of the mechanism supporting its conservation. “This story challenges one of the biggest misconceptions about luxury fashion,” Christy Gilmore said during the program. “Some of the world’s most respected luxury houses rely on legal, fully traceable American alligator leather. That demand has helped create one of the greatest wildlife conservation success stories in history. When consumers choose products backed by science, transparency, and responsible management, they become part of conservation.”

Rebecca Hale, Executive Director of the Louisiana Alligator Farmers and Ranchers Association, emphasized the generations of Louisiana families who have participated in the program and the connection between conservation, farming, and craftsmanship. “Every alligator leather product reflects a legacy of conservation,” Hale said. “Behind each piece is a decades-long commitment to sustainable management, traceability, and stewardship.” She noted that the partnership among wildlife managers, farmers, and leather artisans demonstrates how conservation, craftsmanship, and leather production can work together to support both wildlife populations and local communities.

The recovery of the American alligator cannot be attributed to a single agency, law, organization, or industry. Rather, it has depended on cooperation across an unusually broad network of stakeholders - from government biologists responsible for establishing harvest frameworks and monitoring populations to landowners maintaining habitat, farmers and ranchers participating in regulated production systems, CITES authorities overseeing international trade, and businesses creating markets for legally sourced products.

Following the documentary screening, experts representing USFWS and the states of Louisiana, Florida and Texas discussed the future of American alligator conservation and sustainable wildlife management. The discussion examined the continuing importance of sound science, CITES, international cooperation, habitat conservation, regulated trade, and traceability.

The American alligator story carries lessons extending well beyond a single species. At its core is a recognition that wildlife conservation and human economic activity do not always have to be competing objectives. Under the right conditions, economic value can create powerful incentives for people to conserve wildlife and the landscapes on which it depends.

For the American alligator, science-based management, regulated harvest, farming and ranching, private landowner participation, international trade, CITES oversight, and demand for legally sourced products have developed into an interconnected conservation system. As governments, conservation organizations, and businesses increasingly focus on biodiversity, responsible sourcing, and supply-chain transparency, the American alligator provides a long-running example of these principles in practice. Rigorous traceability, government oversight, private stewardship, responsible markets, and consumer demand have combined to produce measurable conservation outcomes while supporting rural communities and working landscapes.

Once considered a species in serious decline, the American alligator is now abundant across much of its range and recognized internationally as one of conservation's great success stories. "Scales of Success" provided an opportunity not only to celebrate that achievement, but also to recognize the people and institutions that made it possible - and to consider what the experience of the American alligator can teach the wider conservation community.

For the CSG, those lessons are particularly relevant. The American alligator demonstrates that when sustainable use is grounded in science, effective regulation, traceability, habitat stewardship, and collaboration across the entire supply chain, conservation and commerce can reinforce rather than oppose one another.

The challenge for the next generation will be to ensure that these systems remain strong so that the ecological, economic, and conservation benefits created through decades of cooperation continue well into the future.



Figure 3. Alligator industry members.

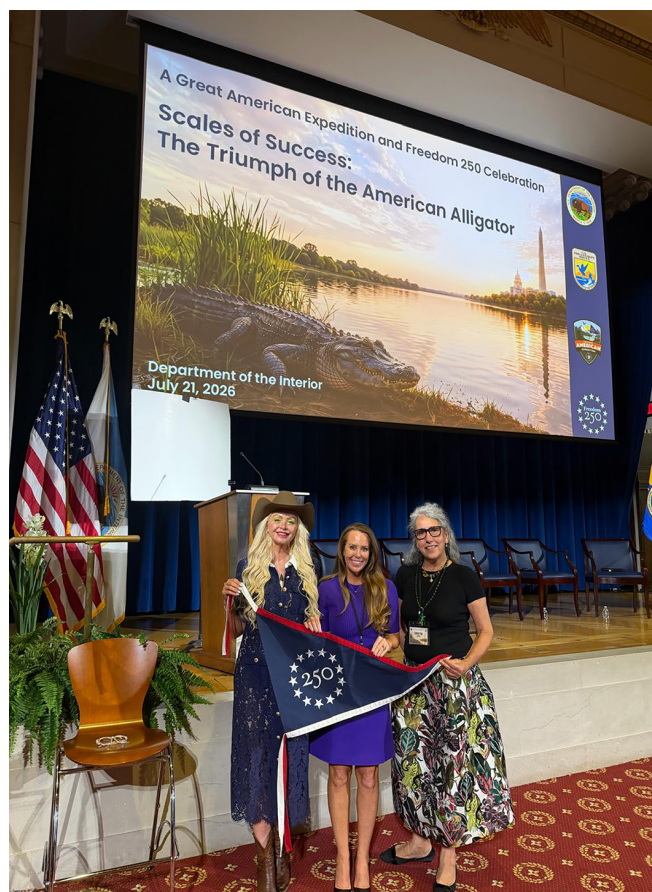


Figure 4. From left, Savannah Boan, Christy Gilmore and Christine Lippai.



Figure 5. Trey Gilmore (documentary narrator) and Christy Gilmore (script writer).

Christy Gilmore, CSG Industry Group Chair.

SEX-SPECIFIC NICHE SEGREGATION OF THE PENTASTOME *SEBEKIA MISSISSIPPIENSIS* IN THE AMERICAN ALLIGATOR (*ALLIGATOR MISSISSIPPIENSIS*). Pentastomes are a group of obligate crustacean endoparasites belonging to the phylum Pentastomida, which comprises 24 valid genera encompassing approximately 124 species (Swanepoel *et al.* 2022). They primarily parasitize the respiratory tracts of reptiles, although infections have been documented in mammalian and avian species, albeit infrequently (Paré 2008). Adult pentastomes possess an elongated vermiform body and a characteristic oral apparatus that consists of two pairs of two retractable hooks that line either side of their mouth (Fig. 1). These hooks are used to attach to the respiratory tissue of their hosts and feed on blood (Paré 2008).

The lifecycles of pentastomes are generally indirect and involve transmission between definitive and intermediate hosts. Adult pentastomes inhabit the respiratory tract of definitive hosts, where females produce and deposit eggs within the lungs. Eggs are subsequently transported to the gastrointestinal tract through mucociliary clearance, and released into the environment in feces. In aquatic systems, eggs may be ingested by suitable fish intermediate hosts, within which the eggs hatch and develop through successive stages to the nymphal stage. Transmission to the definitive host occurs when an infected intermediate host is consumed. Following ingestion, the developing pentastome penetrates the intestinal wall, migrates to the respiratory tract, and ultimately matures and reproduces within the lungs, completing the lifecycle (Yanong 2006).

Three families of pentastomes are recognized as parasites of the Order Crocodylia: Sebekidae, Porocephalidae and Subtriquetridae. For most species within these families, crocodylians serve as the definitive hosts. Although infections are often associated with limited clinical effects, pentastomes may cause some serious pathologies to the host species and heavy pentastome loads can lead to pulmonary edema, hemorrhage, or suffocation of the host (Jacobson 2007). For example, Junker *et al.* (1999) documented the infection of two 3-m long Nile crocodiles (*Crocodylus niloticus*) collected from Kruger National Park, in which the presence of three species of pentastome (*Sebekia* spp.) caused mild coagulative necrosis with heterophilic and eosinophilic infiltrates, and adjacent hemorrhage and oedema at the sites of attachment in one of the crocodiles. The other crocodile appeared severely emaciated, exhibited partial obstructions to both the bronchi and pulmonary aorta, and possessed numerous brown nodules which are representative of the migration tracts and attachment sites of the pentastomes on the external surface of the trachea (Junker *et al.* 1999).

Despite advances in the taxonomy and recognition of pentastome-host associations, fundamental aspects of pentastome biology and their interactions with crocodylian hosts remain incompletely understood. Herein, we provide a theoretical explanation of pentastome niche-segregation between males and females along the respiratory tract of American alligators (*Alligator mississippiensis*). Our theory



Figure 1. *Sebekia mississippiensis*. Source: Overstreet *et al.* (1985).

is based on a field study conducted in 2016 to further investigate pentastome infection in the lungs of alligators in Florida, which was an expansion of previous investigations of pentastomes in alligators in Florida and Louisiana (Tellez *et al.* 2014). Given the pathology of pentastomes to the host, it was deemed significant to further explore the biological site-segregation of the parasite.

All crocodylians elicit an immune response to parasitic infection (ie nematodes, trematodes, and apicomplexans), yet the response is minimal compared to the (beneficial) mutualistic or commensal relationship these symbionts have with their host (Tellez and Sung 2018). However, a caveat about the aforementioned is that the host-parasite dynamic thrives as long as the host is healthy (relatively stress-free environment, clean water, etc.). Polluted environments, poor husbandry in captivity, or other stressful environmental factors can disrupt the host-parasite dynamic, causing once benign symbionts to become parasitic and harmful to the host. Given pentastomes have illustrated a true parasitic relationship with alligators (Tellez 2013), the aim of this report was to provide a theoretical explanation for its pattern of infection. This brief summary seeks to advance the current state of knowledge regarding pentastome infections in crocodylians and to provide baseline information for future researchers investigating pentastome ecology, lifecycle, and pathogenesis.

In August 2014, necropsies on 20 alligators were conducted at George Walrath Alligator Processing in Christmas, Florida during the statewide recreational hunting season (McLinn 2017). Pentastomes were collected from the lungs, trachea, and the opening of the palatal valve of the alligators, and

placed in 70% ethanol. Pentastomes collected from each of the three different sites of infection (lungs, trachea, and palatal valve) were stored in separate vials. All alligators were about 2.4-3 m in length. Unfortunately, data on host sex and exact length were lost due to a computer crash. All parasite samples were examined at the University of California, Santa Barbara. McLinn (2017) identified individuals as *Sebekia mississippiensis*, and noted spatial segregation between male (trachea, palatal valve) and female (lung) pentastomes amongst the three sites within the host.

The sex-specific niche segregation reported by McLinn (2017) is an interesting finding, and one the authors felt was worthy of further exploration and explanation. Similar to non-parasitic species, parasites have evolved to exploit particular locations (within a host) given a preference in some type of resource or nutrient. We hypothesize the apparent biological niche segregation is based on females need for nutrient-rich blood of the host. Pentastomes are hematophagous and use their hooks to burrow or tear tissue to feed on the blood of the host. Females are in higher demand of nutrients to ensure successful reproduction and may compete with males for this nutrient-rich space as documented in other parasite species (Mideo 2009). Thus, based on the findings of McLinn (2017), we hypothesize that female pentastomes remain attached to pulmonary tissues to obtain nutrients, whereas males may reside within the trachea or palatal valve, or occur as free-living individuals, and migrate to respiratory tissues primarily for mating.

We realize more research and parasite collection is required to not only further validate the previous collection of McLinn (2017), but also our hypothesis for the sex-specific niche segregation of *S. mississippiensis*. However, because pentastomes can be problematic for animals in captivity or in ranching/farming programs, we considered it important to report these findings, as they may inform future research on pentastome lifecycles and ecology, which could help mitigate high infection rates *ex-situ*.

We would like to thank Frank Robb for his assistance with necropsies and collecting samples, as well as Dr. Armand Kuris for his guidance and assistance in analysis of the parasite data. We also wish to acknowledge Sierra McLinn for her valuable contributions to the fieldwork and data collection underlying our hypothesis, conducted as part of her undergraduate research, under the mentorship of Dr. Kuris and Dr. Marisa Tellez. Although she left the scientific field several years ago, we would like to acknowledge her work which continues to contribute to scientific knowledge through this article.

Literature Cited

- Jacobson, E.R. (2007). Parasites and parasitic diseases of reptiles. Pp. 590-592 in *Infectious Diseases and Pathology of Reptiles*, ed. by E.R. Jacobson. Taylor & Francis Group: Boca Raton.
- Junker, K., Boomker, J. and Bolton, L.A. (1999). Pentastomid

infections in Nile crocodiles (*Crocodylus niloticus*) in the Kruger National Park, South Africa, with a description of the males of *Alofia simpsoni*. *Onderstepoort Journal of Veterinary Research* 66(2): 65-71.

McLinn, S. (2017). Investigating the Life-cycle of the Deadliest Crocodilian Parasite in North America. Crocodile Specialist Group Student Research Assistance Scheme [Summary Report No. 17/11](#).

Mideo, N. (2009). Parasite adaptations to within-host competition. *Trends in Parasitology* 25(6): 261-268.

Overstreet, R.M., Self, J.T. and Vliet, K.A. (1985). The pentastomid *Sebekia mississippiensis* sp. n. in the American alligator and other hosts. *Proceedings of the Helminthological Society of Washington* 52(2): 266-277.

Paré, J.A. (2008). An overview of pentastomiasis in reptiles and other vertebrates. *Journal of Exotic Pet Medicine* 17(4): 285-294.

Swanepoel, L., Loyola, A., Flowers, J., Lewbart, G.A., Garrett, K.B. and Yabsley, M.J. (2022). Infection with a novel pentastome (*Raillietiella* sp.) in a juvenile endangered Galápagos tortoise (*Chelonoidis niger*). *Veterinary Parasitology: Regional Studies and Reports* 35: 100782.

Tellez, M. (2013). A Checklist of Host-Parasite Interactions of the Order Crocodylia. UC Publications in Zoology: University of California, Berkeley, USA.

Tellez, M., Haghighi, A. and Lavihim, M. (2014). Distribution and abundance of *Sebekia mississippiensis* (Sebekidae) in the American alligator, *Alligator mississippiensis*. *Comparative Parasitology* 81(2): 232-239.

Tellez, M. and Sung, H. (2018). Unveiling the host-parasite dynamic of alligators and their endoparasites. Pp. 177-215 in *American Alligators: Habitats, Behaviors, and Threats*, ed. by S.C. Henke and C. Eversole. Nova Science Publishers: New York City, NY, USA.

Yanong, R.P.E. (2006). Pentastomid Infections in Fish. Publication #FA90, EDIS 2006(7).

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East & Southern Africa

Uganda

SPATIAL RISK LANDSCAPES AND SOCIO-ECOLOGICAL CORRELATES OF FATAL HUMAN-CROCODILE CONFLICT IN WESTERN UGANDA. Human-wildlife conflict (HWC) is a significant conservation

and development challenge worldwide, especially where human populations share landscapes with large predators and aquatic megafauna (Madden 2004; Kanga *et al.* 2012; Matanzima 2024). Among the most dangerous yet understudied forms of HWC are attacks by crocodilians such as the Nile crocodile (*Crocodylus niloticus*) (Aust *et al.* 2009; Sai *et al.* 2016). Across sub-Saharan Africa, crocodile attacks frequently occur in communities that depend on freshwater ecosystems for fishing, transport, and domestic water use, often resulting in high mortality rates (Dunham *et al.* 2010; Wallace *et al.* 2011; Pooley 2016; Powell *et al.* 2020). For example, in Zambia's Lower Zambezi Valley, 62.2% of crocodile attacks between 2000 and 2009 resulted in death, with most attacks occurring during canoe fishing or water collection (Wallace *et al.* 2011).

Studies from South Africa, Tanzania and Uganda consistently show that crocodile attacks disproportionately affect males engaged in water-based livelihood activities, particularly fishing and water collection, underscoring the gendered risk to those engaged in such activities (Wallace *et al.* 2011; Pooley *et al.* 2019; Eustace *et al.* 2022; Ashepet *et al.* 2023). These examples illustrate the severe and recurrent nature of Human-Crocodile Conflict (HCC) across Africa, confirming its status as a critical threat to human safety and a complex challenge for conservation.

Recent conservation research increasingly recognizes that reducing HWC requires understanding not only where conflicts occur, but also why particular landscapes produce disproportionately severe outcomes (Pooley *et al.* 2019; Ashepet *et al.* 2023; Matanzima 2024). Spatially explicit risk landscapes have become an important framework for identifying locations where ecological conditions, human activities, and predator behaviour interact to generate elevated mortality risk (Frank 2014; Sai 2016; Brien *et al.* 2017; Whitaker and Srinivasan 2020). Despite the growing application of this concept to terrestrial carnivores, its use for aquatic apex predators remains limited, particularly in tropical African freshwater systems.

In Uganda, HCC has become an increasing concern in lakeshore and riverine communities adjacent to protected areas. Around Murchison Falls Conservation Area, for example, 84.3% of recorded crocodile attacks between 2012 and 2017 were fatal, with most incidents occurring during fishing and water collection activities (Ashepet *et al.* 2023). Fishing communities are particularly vulnerable because livelihood activities such as shoreline work, canoe fishing, night fishing, and domestic water access frequently overlap with crocodile habitat (Wallace *et al.* 2011; Frank 2014; Chakuya and Gondo 2018). Despite growing reports of attacks in Uganda, fine-scale evidence on the spatial and behavioural drivers of fatal crocodile encounters remains limited.

Recent ecological approaches emphasize that crocodile attacks are not random events but arise from interactions among environmental conditions, human behaviour, and predator ecology (Powell *et al.* 2020). Risk landscape frameworks

demonstrate how spatial features and patterns of human activity create localized zones of elevated attack risk, while the social-ecological systems (SES) theory situates HCC within broader interactions between livelihood dependence, resource access, and ecological processes (Ostrom 2009). These perspectives are important in understanding why certain lakeshore communities or activities experience disproportionately higher mortality despite sharing the same aquatic environment.

Understanding the spatial organization of fatal attacks is therefore essential for moving beyond reactive conflict management toward predictive, evidence-based coexistence planning (Ashepet *et al.* 2023). Identifying spatial risk landscapes can guide investments in infrastructure, community education, and habitat modification while minimizing unnecessary persecution of crocodile populations (Brien *et al.* 2017; Whitaker and Srinivasan 2020).

Preliminary evidence from Lake Edward Basin in western Uganda suggests a persistent and severe threat, with multiple fatal attacks reported in recent years at landing sites such as Kakoni, Rwenjuba and Kyarukara (Basaija 2025). However, these incidents have not been systematically analyzed to determine their temporal trends, spatial concentration, or predictors of fatality. Consequently, interventions remain largely reactive and generalized, with limited understanding of the specific socio-ecological conditions that shape vulnerability among lakeshore communities. Identifying spatial hotspots and high-risk activities is therefore essential for developing targeted mitigation strategies that improve human safety while supporting long-term coexistence with crocodiles.

To address this gap, we conducted a retrospective analysis of verified crocodile attacks recorded between 2006 and 2025 in Katwe-Kabatoro Town Council along the northeastern shoreline of Lake Edward. Specifically, we aimed to:

1. characterize the temporal and demographic patterns of crocodile attacks;
2. examine the spatial distribution of attacks across landing sites/villages; and,
3. identify behavioural and spatial predictors of fatal outcomes.

We hypothesized that fatality risk would vary according to victim age, activity at the time of attack, and attack location. We predicted that activities involving direct water contact, particularly water collection and swimming, would be associated with greater mortality risk than boat-based fishing because of increased physical exposure to crocodiles. Lastly, we predicted fatality risk to differ among landing sites/villages due to variation in habitat structure, crocodile density, shoreline characteristics, and patterns of human water use. By integrating spatial, behavioural, and socio-ecological perspectives, this study provides empirical evidence to support risk-informed management strategies for HCC in Lake Edward basin and similar African freshwater systems.

Methods

Study Area

The study was conducted in Katwe-Kabatoro Town Council, located on the northeastern shoreline of Lake Edward in the Albertine Rift Valley, a globally recognized biodiversity hotspot (Fig. 1). The study area lies approximately between 0.16°S-0.13°S latitude and 29.86°E-29.96°E longitude, covering key human-lake interaction zones, including Kakoni, Kyarukara, Rwenjuba, Kiganda, and Kanyanja landing sites. The area borders Queen Elizabeth National Park, creating a permeable boundary where high-density human activity directly intersects with significant populations of protected wildlife, including Nile crocodiles and other aquatic predators.

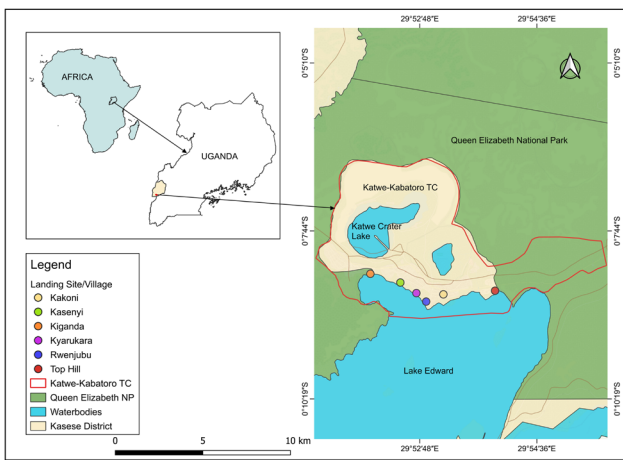


Figure 1. Study area, showing location of Katwe-Kabatoro Town Council, and spatial distribution of documented HCC landing sites and lakeshore communities along the northeastern shoreline of Lake Edward, western Uganda.

The area is characterized by complex socioecological systems comprising fishing communities, salt mining areas along Lake Katwe, and natural aquatic habitats. Livelihood activities include fishing, water collection, and shoreline use, which occur in close overlap with crocodile habitats, making the area a critical hotspot for HCC.

Study design and data collection

We used a mixed-methods, cross-sectional design to compile and analyze a retrospective case series of documented crocodile attacks between 2006 and 2025 (see Fukuda *et al.* 2015). The retrospective case series approach allows the reconstruction of attack histories from multiple sources, providing robust insights into spatial, temporal, and demographic patterns (Sideleau and Britton 2012). Data collection was conducted over six months from January to June 2025, following a pilot phase during October and November 2024. The pilot involved consultations with local chairpersons and the Gombolola/Parish Intelligence and Security Officer (GISO) in Katwe-Kabatoro Town Council, and Uganda Wildlife Authority (UWA) officials to test the data collection template and verify the completeness

of existing documented crocodile attack records. Using a snowball sampling technique (Sideleau and Britton 2012), primary data were gathered through face-to-face interviews with crocodile attack survivors and, in the case of fatal incidents, with immediate family members of the victims. Snowball sampling was employed to ensure comprehensive coverage of incidents that might otherwise be undocumented, particularly in remote landing sites (Noy 2008; Sideleau and Britton 2012). A standardized questionnaire was used to collect information on the date, precise location, victim demographics, activity during the incident, and the outcome (fatality or injury) (Fukuda *et al.* 2015).

To ensure data quality and reduce recall bias, each incident reported by victims or their families was cross-referenced with at least two independent authoritative sources. This included verification with the Local Council (LC) chairpersons of the respective landing sites (Kakoni, Kyarukara, Kiganda, Rwenjuba, Top Hill), the Gombolola Internal Security Officer (GISO) for Katwe-Kabatoro Town Council, and officials from the Uganda Wildlife Authority stationed in the area. This triangulation approach across community, local government, and national authority levels enhanced the reliability and validity of the dataset (Patton 2015). Only incidents verified through this multi-stage verification process were included in the analysis.

Data analysis

Verified crocodile attack records were entered into Microsoft Excel and analyzed using R software (version 4.5.0). Each case was coded by year, landing site, victim age and sex, activity during the incident, and outcome (died or survived). Descriptive statistics, including frequencies, percentages, and cross-tabulations, were used to summarize temporal (yearly) and spatial patterns of attacks (Brien *et al.* 2017).

Spatial analysis was descriptive, with verified cases aggregated by landing site/villages to identify hotspots of Human-crocodile conflict. Geographic coordinates for each landing site were mapped in QGIS software (version 3.44.10 Solothurn). A graduated proportional symbol approach was used to visualize relative attack frequency, while a sequential color gradient representing fatality risk was applied to illustrate spatial variation in fatality risk. Temporal analysis focused on interannual variation across the 2006-2025 period.

Qualitative interview data were transcribed and thematically analyzed to identify recurrent perceptions of risk, and causes of attacks. Findings were then synthesized to generate an integrated understanding of the spatial-temporal dynamics, socio-demographic patterns, and conservation implications of HCC in the Lake Edward Basin.

Eighty (80) verified crocodile incidents were compiled for descriptive analyses. However, one incident from Kasenyi landing site was excluded from regression modelling because the category contained only a single observation, resulting in a final sample size of 79 cases for inferential analyses.

Because the attack outcome was binary (0= survived, 1= died), Firth penalized logistic regression models with a binomial error distribution and a logit link function were used to estimate the probability of fatal outcomes associated with demographic, behavioural, and spatial predictors. Firth penalized likelihood estimation was selected to reduce small-sample bias and address sparse observations within some predictor categories (Firth 1993; Heinze and Schemper 2002).

The response variable was coded as a binary outcome (0= survived, 1= died). Predictor variables included age (continuous), activity during the attack, and spatial location of the incident. Fetching water and Kakoni landing site were specified as the reference categories for activity and location, respectively. Categorical predictors were modeled using treatment contrasts.

Multicollinearity among predictors was assessed using Variance Inflation Factors (VIFs). All GVIF values were below 2 (adjusted GVIF range: 1.04-1.14), indicating no evidence of problematic multicollinearity (Zuur *et al.* 2010).

Three nested models were fitted for comparison: Age-only; Age plus Activity; and, the Full Model, including age, activity, and spatial location. Model performance was evaluated using penalized log-likelihood, likelihood ratio tests, and McFadden's pseudo- R^2 .

Sex was excluded from the models due to the extreme class imbalances (Males= 93.3%), which could introduce estimation instability and reduce model reliability. Interaction terms between activity and location were considered conceptually but were not included due to small sample sizes in several category combinations, which could compromise model stability (Burnham and Anderson 2002). Odds ratios (OR), 95% confidence intervals (CI), and p-values from Firth-penalized logistic regression were reported for all predictors. Statistical significance was assessed at $\alpha=0.05$.

Because the objective was to identify factors associated with fatal outcomes, emphasis was placed on estimating effect sizes and ecological interpretation rather than maximizing model explanatory power (Shmueli 2010).

Results

A total of 80 crocodile attack incidents was recorded in Katwe-Kabatoro Town Council between 2006 and 2025; no verified incidents were recorded in 2007-2012, 2014-2017 and 2019 (Table 1). Of these, 51 (63.7%) were fatal, indicating a fatality rate of 0.637 and survival rate of 0.363. The majority of the victims were male ($n=77$; 96.3%), with only 3 females (3.7%) recorded. The mean age of victims was 25.35 years ($SD=8.49$; range 12 to 50 years).

Spatially, crocodile attacks were distributed across six major landing sites and lakeshore communities (Table 2). Kakoni recorded the highest number of incidents ($n=38$; 47.5%), followed by Kiganda and Rwenjuba (each with 14 incidents; 17.5%), while Kyarukara registered 9 attacks (11.2%). Top

Table 1. Annual distribution of verified crocodile attack incidents and associated fatality rates in Katwe Kabatoro Town Council, Lake Edward Basin, western Uganda. No verified incidents were identified in 2007-2012, 2014-2017 and 2019.

Year	No. of Attacks	----- Outcome -----		Fatality Rate
		Fatal	Non-Fatal	
2006	3	1	2	0.667
2013	1	0	1	1.000
2018	1	0	1	1.000
2020	2	0	2	1.000
2021	7	2	5	0.714
2022	17	8	9	0.529
2023	31	13	18	0.581
2024	15	4	11	0.733
2025	3	1	2	0.667
All	80	29	51	0.363

Table 2. Spatial distribution of crocodile attack incidents across major landing sites and lakeshore communities in Katwe Kabatoro Town Council, Lake Edward Basin, Uganda, 2006-2025.

Location	No. of Attacks	----- Outcome -----		Fatality Rate
		Fatal	Non-Fatal	
Kakoni	38	20	18	0.474
Kiganda	14	5	9	0.643
Rwenjuba	14	3	11	0.786
Kyarukara	9	1	8	0.889
Top Hill	4	0	4	1.000
Kasenyei	1	0	1	1.000
All	80	29	51	0.363

Hill ($n=4$) and Kasenyei ($n=1$) reported the fewest cases.

The fatality rate was highest in Top Hill (1.000), followed by Kyarukara (0.889) and Rwenjuba (0.786), indicating substantial variation in mortality across sites. Kakoni, despite having the highest number of attacks, recorded a comparatively lower fatality rate (0.474). The spatial distribution of attack frequency and associated fatality risk across landing sites/villages is illustrated in Figure 2.

The hotspot map (Fig. 2) further revealed spatial decoupling between attack frequency and fatality severity. Kakoni exhibited the highest attack concentration but comparatively lower fatality risk, whereas Kyarukara and Top Hill demonstrated elevated fatality risk despite lower attack frequencies.

Analysis by activity type revealed that most attacks occurred during fishing ($n=45$; 56.2%), followed by fetching water ($n=18$; 22.5%), washing clothes ($n=14$; 17.5%), and swimming ($n=3$; 3.8%) (Table 3).

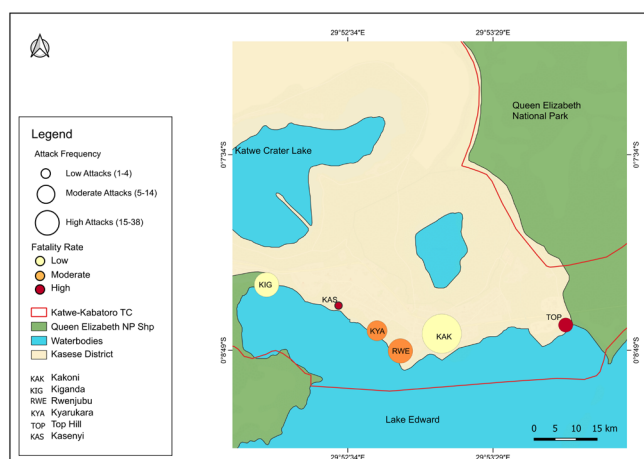


Figure 2. Spatial Hotspot distribution of documented crocodile attack incidents across landing sites/Villages within Katwe-Kabatoro Town Council, Lake Edward Basin, western Uganda, 2006-2025.

Table 3. Distribution of crocodile attack incidents by human activity at the time of attack in Katwe Kabatoro Town Council, Lake Edward Basin, western Uganda, 2006-2025.

Activity	No. of Attacks	----- Outcome -----		Fatality Rate
		Fatal	Non-Fatal	
Fishing	45	18	27	0.600
Fetching water	18	3	15	0.833
Washing clothes	14	7	7	0.500
Swimming	3	1	2	0.667

The fatality rate was highest among individuals fetching water (0.833) and lowest among those washing clothes (0.500) (Table 3). Fishing-related activities, while most frequent, had a moderate fatality rate of 0.600. Overall, fishing and water-fetching jointly accounted for 78.7% of all attacks, underscoring their dominance among crocodile-related incidents in the area (Figs. 3-6).

Among the 29 survivors, the majority sustained severe injuries such as loss of limbs, deep lacerations, and permanent disability. Specifically, 6 (20.7%) individuals suffered amputations, 10 (34.5%) reported deep wounds or body injuries, and 4 (13.8%) sustained long-term physical disabilities. Minor injuries involving surface wounds or soft tissue damage were comparatively rare.

Three Firth penalized logistic regression models were fitted to evaluate the influence of age, activity, and location on the likelihood of fatal outcomes following crocodile attacks (Table 4).

The full model, including age, activity, and location, had the highest penalized log-likelihood and was therefore retained as the most parsimonious model for interpretation. The final model yielded a McFadden's pseudo- R^2 value of 0.11, showing that age, activity and location explained a modest proportion of variation in fatal outcomes.



Figure 3. Fisherman standing waist-deep in shallow water and using traditional fishing methods near a wetland along the Lake Edward shoreline, illustrating potential exposure to crocodile encounters where shallow, accessible waters facilitate close HCC.



Figure 4. Two fishermen standing in shallow water and using a small fishing net along the Lake Edward shoreline, where reeds, grass and exposed dry areas provide potential crocodile habitat, including basking sites.

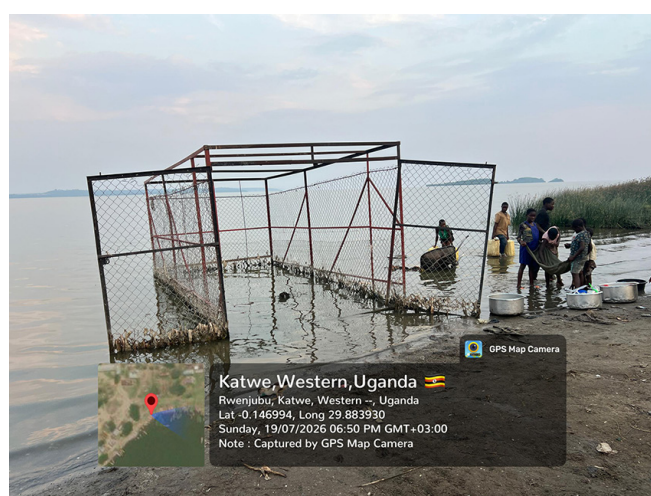


Figure 5. Functional crocodile exclusion enclosure along the Lake Edward shoreline remains unused, while community members access the lake directly to wash utensils and collect water, illustrating the limited use of an available measure intended to reduce HCC.



Figure 6. Worn-out crocodile exclusion enclosure along the Lake Edward shoreline, with community members using the open area outside the cage to access water for washing.

Table 4. Comparison of nested Firth penalized logistic regression models predicting fatal crocodile attack outcomes in Katwe Kabatoro Town Council, Lake Edward Basin, Uganda.

Model	Predictors	Log-Likelihood
Model 1	Age	-46.91
Model 2	Age + Activity	-46.13
Model 3	Age + Activity + Location	-45.09

Both activity type and spatial location were associated with variation in fatal outcomes following crocodile attacks. Compared to individuals fetching water (reference category), victims engaged in fishing had significantly lower probability of fatality (OR= 0.23, 95% CI: 0.04-0.92, $p= 0.037$). Swimming and washing clothes were also associated with reduced odds of fatality relative to fetching water, although these effects were not statistically significant.

Spatial variation in fatality risk was also evident. Relative to Kakoni landing site (reference category), attacks occurring at Kyarukara were associated with substantially higher odds of death (OR= 7.59, 95% CI: 1.26-90.34, $p= 0.025$), while attacks at Rwenjuba also showed significantly elevated fatality risk (OR= 3.88, 95% CI: 1.04-17.93, $p= 0.043$). Attacks occurring at Top Hill also showed substantially elevated odds of fatality (OR= 11.42), although this effect was non-significant ($p= 0.061$). Age was not significantly associated with fatal outcomes (OR= 1.04, 95% CI: 0.97-1.13, $p= 0.26$) (Table 5).

Discussion

Human-crocodile conflict represents a critical conservation and public safety challenge across much of sub-Saharan Africa (Lamarque *et al.* 2009; Ashepet *et al.* 2023), while effective mitigation is often limited by the lack of fine-scale, longitudinal data (Wallace *et al.* 2011; Pooley *et al.*

Table 5. Firth penalized logistic regression analysis examining predictors of fatal outcomes following crocodile attacks in Katwe Kabatoro Town Council, Lake Edward Basin, Uganda ($n= 79$). Note: Model statistics: McFadden's pseudo- $R^2= 0.11$. Significant predictors ($P<0.05$) are shown in bold. Fetching water and Kakoni were used as reference categories for activity and location, respectively.

Predictor	Category	OR	95% CI	p-value
Age	Continuous	1.04	0.97-1.13	0.260
Activity	Fishing	0.23	0.04-0.92	0.037
	Swimming	0.13	0.01-2.31	0.153
	Washing clothes	0.24	0.04-1.18	0.080
	(Reference: Fetching water)			
Location	Kiganda	2.52	0.71-10.14	0.157
	Kyarukara	7.59	1.26-90.34	0.025
	Rwenjuba	3.88	1.04-17.93	0.043
	Top Hill	11.42	0.91-1640.96	0.061
	(Reference: Kakoni)			

2019). This study extends existing understanding of HCC by demonstrating that fatal attacks are spatially structured socio-ecological phenomena rather than random events. The integration of long-term attack records with behavioural and spatial predictors provides empirical evidence supporting risk landscape theory in African freshwater ecosystems.

This 20-year (2006-2025) analysis reveals that the attack rate escalated in the recent five years (2021-2025), with a pronounced demographic skew; 96.3% of victims were male. This pattern aligns with global trends, reflecting that occupational exposure, particularly fishing and water-based livelihoods, is the primary driver of risk rather than random encounters (Wallace *et al.* 2011; Sideleau *et al.* 2017; García and Buenrostro 2018; Whitaker and Srinivasan 2020; Eustace *et al.* 2022).

The temporal clustering of incidents suggests multiple interacting drivers (Sideleau *et al.* 2017), including the recovery of crocodile populations following protection, intensified human resource use due to demographic or economic pressures, or hydrological changes altering human-wildlife overlap (Aust 2009; Sai 2016; Utete 2021; Ashepet *et al.* 2023; Musalo *et al.* 2024). Future research integrating systematic population surveys, telemetry, and socio-ecological monitoring is needed to determine whether the primary lever for intervention lies in managing crocodile populations or modifying human behaviour, or both (Sideleau *et al.* 2017).

Spatial heterogeneity in risk was apparent. Sites differed in fatality rates despite similar attack frequencies, indicating that habitat features and human-use patterns shape outcomes (Frank 2014; Sai 2016; Das and Jana 2018; Whitaker and Srinivasan 2020). The logistic regression model indicated that location was a significant predictor of fatal outcome.

Spatial heterogeneity in fatality risk may reflect variation in habitat and human-use (eg solitary water-use by fishers or water-collectors, some sites may have steeper banks or deeper ambush zones), and higher density of large adult crocodiles (Matanzima 2024; Brundle *et al.* 2025). These findings mirror observations from Zambia, Zimbabwe, and Mozambique, suggesting that attack frequency and lethality are driven by distinct mechanisms and require site-specific management strategies (Chomba *et al.* 2012; Pooley *et al.* 2019; Matanzima 2024). This distinction is critical, as it demonstrates that attack frequency and lethality are driven by different mechanisms, necessitating spatially explicit management responses (Pooley *et al.* 2019; Powell *et al.* 2020).

Activity type strongly influenced fatality risk. Fishing accounted for the majority of attacks (56.2%), but water collection carried the highest probability of death (fatality rate= 83.3%), reflecting differences in exposure, situational vulnerability, and rescue opportunities (Whitaker 2020; Aswani and Matanzima 2024). Similar patterns have been reported globally, including in northern Australia and Mexico, where in-water activities such as swimming, diving, or wading substantially increase fatality risk compared to activities conducted on boats or land (Fukuda *et al.* 2015; García and Buenrostro 2018; Hilário *et al.* 2021). These consistent patterns indicate that direct human contact with water is a primary determinant of both the likelihood and severity of attacks.

Applying a socio-ecological systems framework, HCC emerges as an outcome of interactions between human behaviour, environmental conditions, and wildlife ecology, rather than solely the presence of crocodiles (Ostrom 2009; Morzillo *et al.* 2014). Solitary shoreline users face the greatest danger, whereas group-based fishing or water activities reduce risk by enabling prompt rescue or deterrence of attacks (Scott *et al.* 2014; Khan *et al.* 2020).

Management implications are clear. Interventions should focus on high-lethality contexts, such as nearshore water use, through infrastructure improvements (eg fenced or raised water-access points, safe landing zones, lighting) (Amarasinghe *et al.* 2015; Das and Jana 2018; Whitaker and Srinivasan 2020), promotion of group-based fishing or water collection, and community education tailored to high-risk activities and times (Sideleau *et al.* 2017) (Fig. 7). Habitat modifications, such as reducing ambush cover near access points, should be considered alongside cautious evaluation of lethal control measures, given global evidence of ecological and economic ineffectiveness (Pooley 2024).

Non-fatal attacks (n= 29; 36.3%) imposed substantial morbidity, including amputations and permanent musculoskeletal damage, which compromise livelihood activities and create household-level economic consequences, such as loss of income and unplanned medical expenditures (García *et al.* 2020; Bhengu *et al.* 2021). Accounting for both mortality and long-term morbidity is essential when evaluating the societal value of mitigation interventions.



Figure 7. Field researcher beside a crocodile warning sign at a Lake Edward landing site in Katwe-Kabatoro Town Council.

Although this study provides one of the first long-term assessments of HCC in Lake Edward Basin, some limitations were encountered. Firstly, the retrospective design relied partly on participant recall, which may have introduced potential recall inaccuracies in the timing and circumstances of some historical incidents. However, we applied a multistage verification process involving survivors, victim families, local leaders, and Uganda Wildlife Authority staff, substantially improving the reliability of the attack records used in the analysis. Secondly, the relatively small sample size and uneven distribution of attacks across locations and activities limited statistical power for some comparisons. This was reflected in the wide confidence intervals observed for certain predictor categories. Nevertheless, the use of Firth penalized logistic regression reduced potential bias arising from sparse data and rare events categories. Thirdly, temporal trends were evaluated descriptively rather than incorporated into predictive models because attack records were highly uneven across years. Future studies with systematic long-term monitoring are recommended to evaluate the influence of temporal drivers such as climate variability, hydrological conditions, changing crocodile populations, and shifts in human resource use patterns.

Conclusions

This study demonstrates that fatal HCC in western Uganda is structured by spatially explicit socio-ecological processes that create localized risk landscapes. The findings shift attention from generalized conflict mitigation toward targeted coexistence strategies informed by spatial ecology and human behaviour. By integrating conservation science, spatial analysis, and community livelihoods, this work provides an evidence base for designing interventions that protect both human lives and crocodile populations across African freshwater ecosystems.

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Literature Cited

- Amarasinghe, A.T., Madawala, M., Karunarathna, D., Manolis, S.C., De Silva, A. and Sommerlad, R. (2015). Human-crocodile conflict and conservation implications of saltwater crocodiles *Crocodylus porosus* (Reptilia: Crocodylia: Crocodylidae) in Sri Lanka. *Journal of Threatened Taxa* 7(5): 7111-7130.
- Ashepet, J., Boonen, C., Jansen, M. and Jacobs, L. (2023). Contextualizing human-crocodile conflict in Uganda: A political ecology perspective. *Journal of Wildlife Management* 87(2): 345-359.
- Ashepet, M.-G., Dahdouh-Guebas, F., Redpath, S., Pooley, S. and Huge, J. (2023). The state and perceptions of human-crocodile interactions around Murchison Falls Conservation Area, Uganda. *Human Dimensions of Wildlife* 29(2): 194-209.
- Aswani, S. and Matanzima, J. (2024). Human-crocodile interactions in the western Solomon Islands: the importance of local data for reducing attacks on people. *Oryx* 58(3): 344-346.
- Aust, P.W. (2009). The Ecology, Conservation and Management of Nile Crocodiles *Crocodylus niloticus* in a Human Dominated Landscape. PhD thesis, Imperial College London, UK.
- Aust, P., Boyle, B., Fergusson, R. and Coulson, T. (2009). The impact of Nile crocodiles on rural livelihoods in northeastern Namibia. *South African Journal of Wildlife Research* 39(1): 57-69.
- Basaija, I. (2025). Crocodile mauls 30-year-old man on Lake Edward in Kasese District. [Uganda Radio Network, 20 April 2025](#).
- Bhengu, C., Mbanjwa, B. and Ntuli, S. (2021). A 5-year review of crocodile attacks on humans in the iSimangaliso Wetland Park, KwaZulu-Natal, South Africa. *The South African Medical Journal* 111(8): 752-755.
- Brien, M.L., Gienger, C.M., Browne, C.A., Read, M.A., Joyce, M.J. and Sullivan, S. (2017). Patterns of human-crocodile conflict in Queensland: A review of historical estuarine crocodile (*Crocodylus porosus*) management. *Wildlife Research* 44(4): 281-290.
- Brundle, K., Labuschagne, L. and Booth, A. (2025). Nile crocodiles in Lake Nasser, Egypt, are found close to fishermen's camps, indicating potential conflicts. *Journal of Arid Environments* 216: 104-124.
- Burnham, K.P. and Anderson, D.R. (2002). *Model Selection and Multimodel Inference: A Practical Information-theoretic Approach*, 2nd edition. Springer.
- Chakuya J. and Gondo R., (2018). The human crocodile conflicts and the sustainable conflict resolutions review. *International Journal of Environmental Science and Natural Resources* 13(2): 555856.
- Chomba, C., Senzota, R., Chabwela, H., Mwitwa, J. and Nyirenda, V. (2012). Patterns of human-wildlife conflicts in Zambia, causes, consequences and management responses. *Journal of Ecology and the Natural Environment* 4(12): 303-313.
- Das, C.S. and Jana, R. (2018). Human-crocodile conflict in the Indian Sundarban: An analysis of spatio-temporal incidences in relation to people's livelihood. *Oryx* 52(4): 661-668.
- Dunham, K.M., Ghiurghi, A., Cumbi, R. and Urbano, F. (2010). Human-wildlife conflict in Mozambique: A national perspective, with emphasis on wildlife attacks on humans. *Oryx* 44(2): 185-193.
- Eustace, A., Gunda, D.M., Mremi, R., Sanya, J., Kamili, E., Munuo, W.A., Saigilu, M.M., Martin, E.H., Kisingo, A. W. and Kahana, L. (2022). Patterns pertaining to crocodile attacks on humans in Tanzania: Baseline data to support mitigation measures. *Human Ecology* 50(6): 953-961.
- Eustace, A., Kisingo, A. and Jones, B. (2022). Patterns and drivers of human-crocodile conflict in Tanzania: A multi-site analysis. *Global Ecology and Conservation* 38: e02214.
- Frank, Z. (2014). Human-Crocodile Conflicts in Areas Adjacent to Lake Rukwa and Momba River, Momba District, Tanzania. MSc thesis, Sokoine University of Agriculture, Morogoro, Tanzania.
- Fukuda, Y., Manolis, C., Saalfeld, K. and Zuur, A. (2015). Dead or alive? Factors affecting the survival of victims during attacks by Saltwater crocodiles (*Crocodylus porosus*) in Australia. *PloS One* 10(5): e0126778.
- García Grajales, J. and Buenrostro Silva, A. (2018). Crocodile attacks in Oaxaca, Mexico: An update of its incidences and consequences for management and conservation. *Acta Universitaria* 28(5): 1-8.
- Garcia, C.A., O'Kelly, H., Piana, R.P. and Tovar, C. (2020). The economic burden of human-wildlife conflict in the agricultural sector of a developing country. *Biological Conservation* 248: 108693.
- Heinze, G. and Schemper, M. (2002). A solution to the problem of separation in logistic regression. *Statistics in*

- Medicine 21(16): 2409-2419.
- Kanga, E. M., Ogutu, J. O., Piepho, H. P. and Olff, H. (2012). Human-hippo conflicts in Kenya during 1997-2008: vulnerability of a megaherbivore to anthropogenic land use changes. *Journal of Land Use Science* 7(4): 395-406.
- Lamarque, F., Anderson, J., Fergusson, R., Lagrange, M., Osei-Owusu, Y. and Bakker, L. (2009). Human-Wildlife Conflict in Africa: Causes, Consequences and Management Strategies. Food and Agriculture Organization of the United Nations.
- Madden, F. (2004). Creating coexistence between humans and wildlife: Global perspectives on local efforts to address human-wildlife conflict. *Human Dimensions of Wildlife* 9(4): 247-257.
- Matanzima, J. (2024). Negative human-wildlife interactions at Lake Kariba: Emphasis on crocodile and hippo attacks on people. Pp. 135-172 in *The Materiality of Lake Kariba*. Palgrave MacMillan: Singapore.
- Morzillo, A.T., De Beurs, K.M. and Martin-Mikle, C.J. (2014). A conceptual framework to evaluate human-wildlife interactions within coupled human and natural systems. *Ecology and Society* 19(3): 44.
- Musalo, B., Chomba, C., Bwalya, E. and Hazyondo, M. (2024). Examining the influence of climate change on human-wildlife conflict in Mosi-Oa-Tunya and Sioma Ngwezi National Parks. *Texila International Journal of Academic Research* 12(3): Article 27.
- Noy, C. (2008). Sampling knowledge: The hermeneutics of snowball sampling in qualitative research. *International Journal of Social Research Methodology* 11(4): 327-344.
- Ostrom, E. (2009). A general framework for analyzing sustainability of social-ecological systems. *Science* 325(5939): 419-422.
- Patton, M.Q. (2015). *Qualitative Research & Evaluation Methods: Integrating Theory and Practice*, 4th edition. Sage Publications.
- Pooley, S. (2016). A cultural herpetology of Nile crocodiles in Africa. *Conservation and Society* 14(4): 391-405.
- Pooley, S. (2024). *A Bibliography of Human-Crocodile Conflict Research and Reports*, 5th edition. Simon Pooley: London.
- Pooley, S., Botha, H., Combrink, X. and Powell, G. (2019). Synthesizing Nile crocodile *Crocodylus niloticus* attack data and historical context to inform mitigation efforts in South Africa and Eswatini. *Oryx* 56(1): 82-90.
- Powell, G., Versluys, T.M.M., Williams, J.J., Tiedt, S. and Pooley, S. (2020). Using environmental niche modelling to investigate abiotic predictors of crocodilian attacks on people. *Oryx* 54(5): 639-647.
- Sai, M., Utete, B., Chinoitezvi, E., Moyo, G.H. and Gandiwa, E. (2016). A survey of the abundance, population structure, and distribution of Nile crocodiles (*Crocodylus niloticus*) using day ground surveys in Sengwa Wildlife Research Area, Zimbabwe. *Herpetological Conservation and Biology* 11(42): 433.
- Scott, G., Tran, A. and Britton, A.R.C. (2014). Risk factors in crocodile attacks in the Northern Territory of Australia: victim characteristics and position at the time of attack. *Wildlife Research* 41(7): 560-567.
- Shmueli, G. (2010). To explain or to predict? *Statistical Science* 25(3): 289-310.
- Sideleau, B.M., Edyvane, K.S. and Britton, A.R. (2017). An analysis of recent saltwater crocodile (*Crocodylus porosus*) attacks in Timor-Leste and consequences for management and conservation. *Marine and Freshwater Research* 68(5): 801-809.
- Sideleau, B. and Britton, A.R.C. (2012). A preliminary analysis of worldwide crocodilian attacks. Pp. 111-114 in *Crocodiles*. Proceedings of the 21st Working Meeting of the IUCN-SSC Crocodile Specialist Group. IUCN: Gland, Switzerland.
- Utete, B. (2021). A review of the conservation status of the Nile crocodile (*Crocodylus niloticus* Laurenti, 1768) in aquatic systems of Zimbabwe. *Global Ecology and Conservation* 29: e01743.
- Wallace, K.M., Leslie, A.J. and Coulson, T. (2011). Living with predators: A focus on the issues of human-crocodile conflict within the lower Zambezi valley. *Wildlife Research* 38(8): 747-755.
- Whitaker, N. and Srinivasan, M. (2020). Human crocodile conflict on the Cauvery River delta region, Tamil Nadu, south India. *International Journal of Fisheries and Aquatic Studies* 8(5): 1-5.
- Zuur, A.F., Ieno, E.N. and Elphick, C.S. (2010). A protocol for data exploration to avoid common statistical problems. *Methods in Ecology and Evolution* 1(1): 3-14.
- Abraham Mugoya Wayirawo, Emmanuel Mukasa and Ivan Kaddu, *Herp Fauna Foundation, Kampala, Uganda*.

Latin America & the Caribbean

Cuba

OBSERVING CUBAN CROCODILE BEHAVIOUR AT ZAPATA CROCODILE FARM. The Cuban crocodile,

Crocodylus rhombifer, is an athletic species that is extremely capable on land (McMahan *et al.* 2019; Targarona *et al.* 2010). While these facets of their biology make them challenging captives (Neill 1971), these characteristics also make *C. rhombifer* behaviourally distinct from other crocodilians and an interesting candidate for behavioural research. Zapata Crocodile Farm (ZCF) houses the largest population of *C. rhombifer* in the world, with several thousand occupying its grounds at any given time. In addition to a large, naturalistic adult breeding enclosure, ZCF has smaller outdoor enclosures that house a variety of ages and densities of crocodiles. The primary goals of management at ZCF include educational outreach and conservation breeding for repatriation into the wild. Regardless of keeping intent, assessing stocking densities and minimizing agonistic interactions in captive crocodilians is an important aspect of captive management. Stocking density can have consequences on growth (Garrett and Murray 1986; Elsey *et al.* 1990; Ramo *et al.* 1992; Campbell *et al.* 2016; Brien *et al.* 2016; Webb *et al.* 2021; Martínez-Cárdenas 2022; Ortega *et al.* 2023), and agonistic interactions can result in mortality (Verdade 1992).

Behavioural observations in crocodilians are mostly associated with adults and reproduction (Cott 1961; Pooley 1969; Garrick and Lang 1977; Garrick *et al.* 1978; Vliet 1989; Thorbjarnarson 1991; Thorbjarnarson and Hernández 1993; Augustine and Watkins 2015; Augustine *et al.* 2017), however observations of aggressive behaviours in juvenile crocodilians have been documented for several species (Blake and Loveridge 1975; Webb *et al.* 1982; Mörpurgo *et al.* 1993; Brien *et al.* 2013a,b,c). Previous observations of adult *C. rhombifer* at the Smithsonian's National Zoo documented similar behavioural repertoires to those seen in other species (Murphy *et al.* 2016; Augustine *et al.* 2015, 2017) and included chases, inflated posture, tail wags, and lunges (Garrick and Lang 1977; Lang 1987; Vliet 1989; Webb and Manolis 1989; Brien *et al.* 2013a,b,c, 2016). As *C. rhombifer* is considered to be an aggressive and highly territorial species of crocodilian (Wise 1994; Trutnau and Sommerlad 2006; Targarona *et al.* 2010), juvenile interactions would likely include high incidences of agonistic behaviours, possibly similar to those documented in *C. porosus* (Brien *et al.* 2013a,b,c).

Herein, we observed three housing arrangements of *C. rhombifer* at ZCF (Table 1) using an ethogram adapted from Brien (2013c; Table 2) to assess differences in behaviour between enclosures, and potential agonistic behaviours that may impact animal welfare. Animals were observed in 30-minute intervals between 0800 and 1800 h by two different observers in October 2019.

A total of 616 behaviours was observed, with the majority, (65.7%) occurring in Pen A2, which housed 18 hatchling crocodiles (<1 year of age). The most frequently observed behaviours were postures (48.7%) followed by contact (15.1%), initiation (14.8%), and termination (13.6%). Postures were the most common behaviours seen in every pen (Fig. 1). Much like *C. johnstoni* (Brien *et al.* 2013c) and *C. porosus* (Brien *et al.* 2013a), *C. rhombifer* exhibited a diverse repertoire of postures (n= 7), non-contact movements (n= 4),

Table 1. Enclosure size, animal density (Male:Female:Unknown sex), and number of behaviours observed in three pens at Zapata Crocodile Farm during 30-minute observation periods.

Pen	Pen Area (m ²)	Animals (M:F:Unk)	Age	No. of 30-min Periods	No. of Behaviours
A2	24	0.0.18	<1 year	19 (570 min)	405
B1	81	1.3.0	adult	21 (630 min)	130
Película	200	1.15.0	adult	19 (570 min)	81

and contact movements (n= 8) (Table 3). Behaviours were observed throughout the day, with 59.7% of observations in the morning (Fig. 2), of which 49.7% were postures (Fig. 1).

Hatchling were housed in A2 at a stocking density of 0.75 animals/m², with 0.7 behaviours observed per minute (Table 1). This is a relatively low density compared to *C. porosus*, which were stocked at densities ranging from 3.3 to 20 hatchlings/m² for a study on growth and behavior (Brien *et al.* 2016). This study found that growth rates declined at higher densities; however, dominance hierarchies were formed at lower densities (Brien *et al.* 2016). The frequency of agonistic behaviours observed in the hatchling *C. rhombifer* at ZCF was significantly higher than that documented in the seven species of juvenile crocodilian previously studied, with an average of 30.8 agonistic observations per night (16 hours), or 0.03 behaviours per minute documented from four species: *C. porosus*, *C. johnstoni*, *C. siamensis* and *Alligator mississippiensis* (Brien *et al.* 2013c). For comparison, as the most aggressive of the extant crocodilians (Lang 1987), *C. porosus* juveniles averaged 24.7 agonistic interactions per night, or 0.026 behaviours per minute when housing density was 0.43/m² (Brien *et al.* 2013c). Observations on juveniles of several species of crocodilians documented 960 agonistic observations during nighttime recordings, with a majority of interactions occurring between 1600-2200 h and minimal interactions observed during the daytime (Brien *et al.* 2013c). It appears that hatchling *C. rhombifer* exhibit the greatest diversity of behaviours and are exhibiting these behaviours during the daytime, unlike the other species studied (Table 3). Previous studies on adult *C. rhombifer* also documented reproductive and agonistic interactions during the day (Augustine *et al.* 2015, 2017).

During these observations, the adult crocodiles were housed at much lower densities, 0.04/m² in B1 (Fig. 3) and 0.08/m² in Película (Fig. 4), and demonstrated far fewer behavioural interactions than the hatchlings (Table 1). This study took place in October, just before breeding season for this species, which typically spans November through April (Targarona *et al.* 2010). Nest defense has been documented in several crocodilian species both in captivity (Alvarez del Toro 1969; Garrick and Lang 1977; Acharjyo 1981; Widholzer *et al.* 1986; Alcalá *et al.* 1987; Vliet 2001) and the wild (Cott 1961; Deitz and Hines 1980; Joanen and McNease 1989; Henaut and Charruau 2012), and increases in agonistic behaviours were seen in *C. rhombifer* at the Smithsonian's National Zoo during nesting season (Augustine *et al.* 2017).

Table 2. Ethogram of behaviours adapted from Brien *et al.* (2013c)(*) or from this paper (**).

Category	Behaviour	Abbreviation	Definition	
Initiation	Rapid advance	RA	Series of rapid advance movements towards another individual while Low In Water	*
	Slow advance	SA	Slow movement towards another individual in a Low In Water posture	**
Termination	Slow flight	SF	Slow movement away from another individual in a Low In Water posture	*
	Rapid flight	RF	Rapid movement away from another individual in a Low In Water posture	*
Posture	Low in water	LIW	Immobile while the top of the head and back are above the water surface	*
	Inflated posture	IP	Immobile with upward extension of either the front two or all four limbs, with neck and back arched high and head and tail angled downward	*
	Head and tail raised	HTR	Immobile with head and tail raised out of water while back remains low Head is usually parallel to the water but can also be angled upwards	*
	Head raised high	HRH	Immobile with upward extension of the head high out of the water on a ~445 degree angle while tail remains low	*
	Mouth agape	MA	Immobile with mouth open wide (in combination with postures LIW, IP, HTR, HRH)	*
	Submissive head down	SHD	Lowering the head down in response to the approach of another animal	**
	Submissive head raise	SHR	Raising the head up in response to the approach of another animal	**
Non-Contact	Light jaw clap	LJC	Rapid opening and closing of the jaws at the water surface, often repeated several times (Low In Water posture)	*
	Tail wagging	TW	Undulation of the tail from side to side in either a gentle or sweeping motion or rapid twitching, often repeated several times (all postures)	*
	Inflated tail sweep	ITS	In an inflated posture, the whole tail is swept side to side in a slow and deliberate fashion as the individual approaches another. This becomes more rapid, and the tail is thrashed from side to side	*
	Vocalization	V	Vocalization observed and confirmed from body movement	*
Contact Movement	Head push	HP	Head is pushed into an opponent, usually with mouth closed (Low In Water posture)	*
	Push down	PD	Chest and neck of the individual pushed down on the upper neck or back of an opponent (Head Raised High posture)	*
	Bite	B	Jaws closed shut on an opponent (all postures)	*
	Side head-strike	SHS	Head is thrust sideways into an opponent while the mouth is either open or shut (all postures)	*
	Tail-wag side head strike	TWSHS	Tail wag side head-strike	*
	Tail-wag bite	TWB	Tail wagging occurs before a bite and propels the individual into an opponent with force (Low In Water posture)	*

These types of studies are critical for developing and evaluating housing arrangements for critically endangered species such as *C. rhombifer* that incorporate conservation breeding programs as part of their recovery strategies (McMahan *et al.* 2022). Studying the behaviour of crocodilians can be informative for animal managers when assessing health issues, stressors, population management, and inform enclosure adjustments or changes (Nevarez 2019). Evaluating animal welfare, particularly for crocodilians, should include observing and documenting behavioural interactions and social dynamics

to minimize agonistic interactions and enhance overall well-being. Further studies at ZCF during breeding and nesting season could reveal a higher rate of interactions to inform management decisions for stocking densities and social groupings in adult animals.

Literature Cited

Acharjyo, L.N. (1981). Egg laying and nest guarding behavior of estuarine crocodile (*Crocodylus porosus*, Schneider) in

Table 3. Presence (x) of various postures, non-contact movements and contact movements displayed by juvenile crocodilians (including hatchlings). Adapted from Brien *et al.* (2013c). Am: *Alligator mississippiensis*, Cj: *Crocodylus johnstoni*, Cnn: *C. novaeguineae*, Cp: *C. porosus*, Cr: *C. rhombifer*, Cs: *C. siamensis*, Gg: *Gavialis gangeticus*, Pp: *Paleosuchus palpebrosus*.

Category	Behaviour	Am	Cj	Cnn	Cp	Cr	Cs	Gg	Pp
Initiation	Rapid advance		x	x	x	x			
	Slow advance					x			
Termination	Slow flight	x	x	x	x	x	x	x	x
	Rapid flight		x	x	x	x			
Posture	Low in water	x	x	x	x	x	x	x	x
	Inflated posture			x	x	x			
	Head and tail raised				x	x			
	Head raised high		x		x	x		x	x
	Mouth agape	x	x	x	x	x		x	x
Non-Contact	Light jaw clap		x		x	x			
	Tail wagging		x	x	x	x			x
Contact Movement	Head push	x	x	x	x	x	x	x	x
	Push down		x			x			
	Bite	x	x	x	x	x	x	x	x
	Side head-strike		x	x	x	x			x
	Tail-wag side head-strike					x	x		
	Tail wag-bite		x	x	x	x	x		

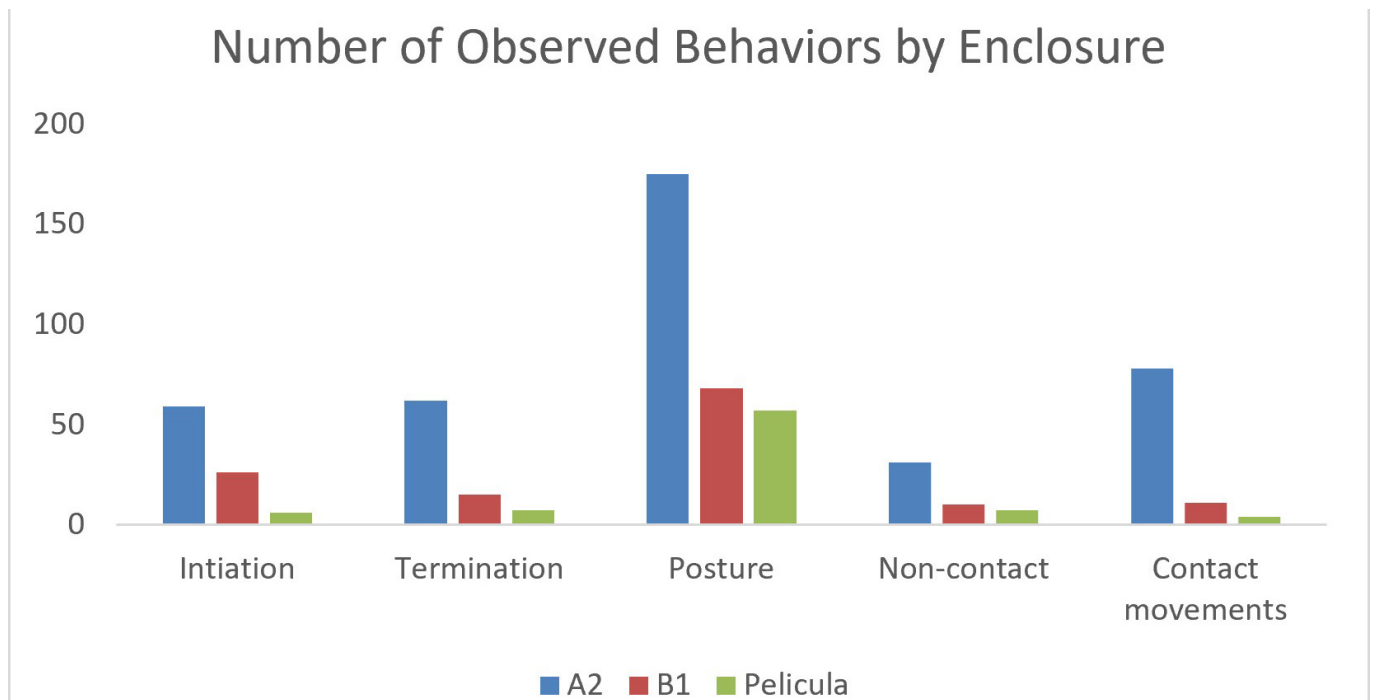


Figure 1. Number of behavioural observations by enclosure and category. Initiation and termination behaviours fall under the non-contact category.

captivity. Journal of the Bombay Natural History Society 78: 387-389.

Silliman Journal 34: 18-28.

Alcala, A.C., Ross, C.A. and Alcala, E.L. (1987). Observations on reproduction and behavior of captive Philippine crocodiles (*Crocodylus mindorensis*, Schmidt).

Alvarez del Toro, M.A.D. (1969). Breeding the Spectacled caiman *Caiman crocodilus* at Tuxtla Gutierrez Zoo. International Zoo Yearbook 9(1): 35-36.

Number of Behaviors by Time of Day

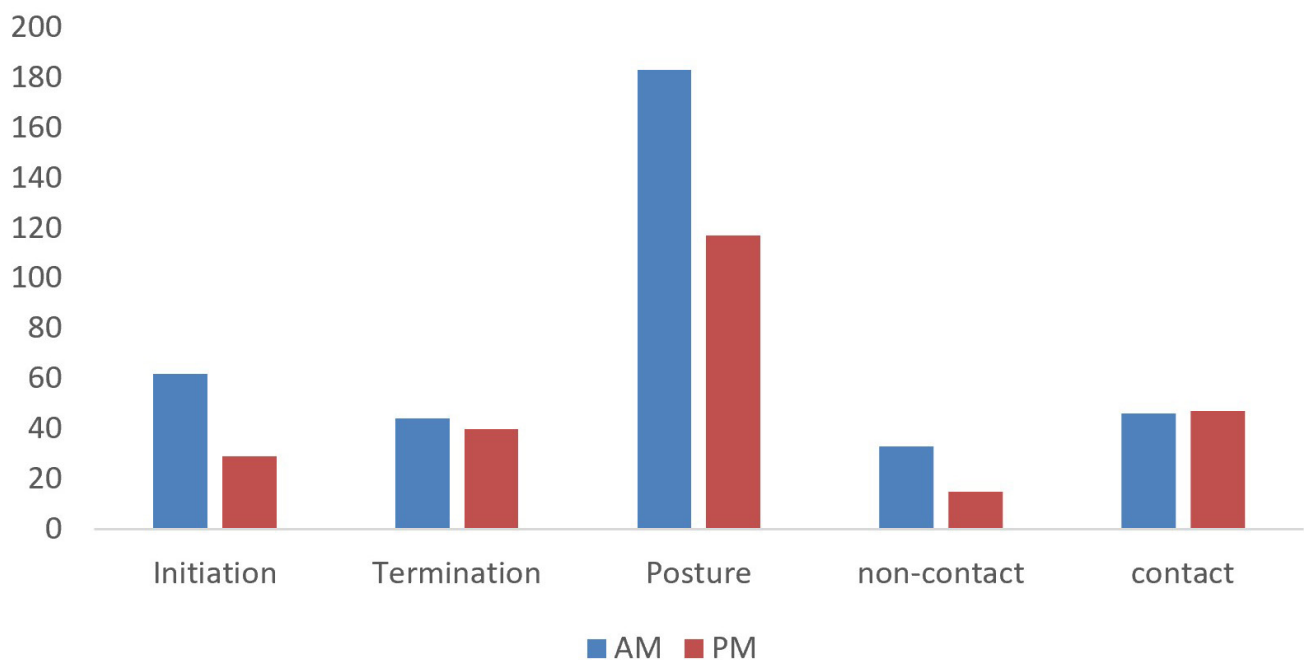


Figure 2. Number of behavioural observations by time of day, using 0800-1230 h as AM and after 1230-1730 h as PM. Initiation and termination behaviours fall under the non-contact category.



Figure 3. Pen B1 at Zapata Crocodile Farm, Cuba.



Figure 4. Pelicula Pen at Zapata Crocodile Farm, Cuba.

Augustine, L. and Watkins, B. (2015). Age, fertility and reproductive behavior in Cuban crocodiles, *Crocodylus rhombifer*, at the Smithsonian's National Zoological Park. *Zoo Biology* 34(3): 278-284.

Augustine, L.A., Pries, K.A. and Evans, M.A. (2017). Social behavior in captive Cuban crocodiles (*Crocodylus rhombifer*) at the Smithsonian's National Zoological Park. *Herpetological Review* 48(1): 75-82.

Blake, D.K. and Loveridge, S.P. (1975). The role of commercial crocodile farming in crocodile conservation. *Biological Conservation* 8: 261-272.

Brien, M.L., Webb, G.L., Lang, J.W., McGuinness, K.A.

and Christian, K.A. (2013a). Born to be bad: Agonistic behaviour in hatchling saltwater crocodiles (*Crocodylus porosus*). *Behavior* 150(7): 737-762.

Brien, M.L., Webb, G.L., Lang, J.W. and Christian, K.A. (2013b). Intra- and interspecific agonistic behaviour in hatchling Australian freshwater crocodiles (*Crocodylus johnstoni*) and saltwater crocodiles (*Crocodylus porosus*). *Australian Journal of Zoology* 61(3): 196-205.

Brien, M.L., Lang, J.W., Webb, G.L., Stevenson, C. and Christian, K.A. (2013c). The good, the bad, and the ugly: Agonistic behaviour in juvenile crocodilians. *PloS ONE* 8(12): e80872.

- Brien, M.L., Webb, G.L., McGuinness, K.A. and Christian, K.A. (2016). Effect of housing density on growth, agonistic behaviour, and activity in hatchling saltwater crocodiles (*Crocodylus porosus*). *Applied Animal Behavior Science* 184: 141-149.
- Campbell, D.L., Hewitt, L., Lee, C., Timmerhues, C.A. and Small, A.H. (2024). Behaviours of farmed saltwater crocodiles (*Crocodylus porosus*) housed individually or in groups. *Frontiers in Veterinary Science* 11: 1394198.
- Cott, H. (1961). Scientific results of an inquiry into the ecology and economic status of the Nile crocodile (*Crocodylus niloticus*) in Uganda and Northern Rhodesia. *The Transactions of the Zoological Society of London* 29(4): 211-356.
- Deitz, D.C. and Hines, T.C. (1980). Alligator nesting in north-central Florida. *Copeia* 2: 249-258.
- Elsey, R.M., Joanen, T., McNease, L. and Lance, V. (1990). Growth rate and plasma corticosterone levels in juvenile alligators maintained at different stocking densities. *Journal of Experimental Zoology* 255(1): 30-36.
- Garnett, S.T. and Murray, R.M. (1986). Parameters affecting the growth of the Estuarine crocodile, *Crocodylus porosus*, in captivity. *Australian Journal of Zoology* 34(2): 211-223.
- Garrick, L.D. and Lang, J.W. (1977). Social signals and behaviors of adult alligators and crocodiles. *American Zoologist* 17(1): 225-239.
- Garrick, L.D., Lang, J.W. and Herzog, H.A. (1978). Social signals of adult American alligators. *Bulletin of American Museum of Natural History* 160: 153-192.
- Hénaut, Y. and Charruau, P. (2012). Nest attendance and hatchling care in wild American crocodiles (*Crocodylus acutus*) in Quintana Roo, Mexico. *Animal Biology* 62(1): 29-51.
- Joanen, T. and McNease, L. (1989). Ecology and physiology of nesting and early development of the American alligator. *American Zoologist* 29: 987-998.
- Lang, J.W. (1987). Crocodilian behaviour: Implications for management. Pp. 273-294 in *Wildlife Management: Crocodiles and Alligators*, ed. by G.J.W. Webb, S.C. Manolis and P.J. Whitehead. Surrey Beatty & Sons: Chipping Norton.
- Martinez-Cárdenas, L., Torres-Aguilar, J.L., Espinosa-Chaurand, D., León-Fernández, A.E., Galaviz-Villa, I., Hernández-Vázquez, F., Castillo-Vargasmachuca, S.G. and Álvarez-González, C.A. (2022). Effect of different stocking densities in juveniles of American crocodile (*Crocodylus acutus*, Crocodylia, Crocodylidae) in captivity. *Agro Productividad* 15(6): 65-74.
- McMahan, W., Targarona, T.R., Soberon, R.R. and Tabet, M.A. (2019). Cuban Crocodile *Crocodylus rhombifer*. Pp. 8 in *Crocodiles. Status Survey and Conservation Action Plan. Fourth Edition*, ed. by S.C. Manolis and C. Stevenson. Crocodile Specialist Group: Darwin.
- McMahan, W., Targarona, T.R., Soberon, R. and Alonso Tabet, M. (2022). *Crocodylus rhombifer*. The IUCN Red List of Threatened Species 2022: e.T5670A130856048.
- Morpurgo, B., Gvoryahu, G. and Robinson, B. (1993). Aggressive behaviour in immature captive Nile crocodiles, *Crocodylus niloticus*, in relation to feeding. *Physiology and Behavior* 53(6): 1157-1161.
- Murphy, J.B., Evans, M., Augustine, L. and Miller, K. (2016). Behaviors in the Cuban crocodile (*Crocodylus rhombifer*). *Herpetological Review* 47(2): 235-240.
- Neil, W.T. (1971). *The Last of the Ruling Reptiles. Alligators, Crocodiles, and their Kin*. Columbia University Press: New York.
- Nevarez, J.G. (2019). Differential diagnoses by clinical signs - crocodilians. Pp. 1276-1282 in *Mader's Reptile and Amphibian Medicine and Surgery*, ed by S.J. Divers and S. J. Stahl. Elsevier Inc: Saint Louis.
- Ortega, S., Hilevski, S. and Hernandez, O. (2023). Captive breeding of *Crocodylus intermedius* (Graves 1819) under different stocking densities. *Herpetology Notes* 16: 941-948.
- Pooley, A.C. (1969). Preliminary studies on the breeding of the Nile crocodile *Crocodylus niloticus* in Zululand. *Lammergeyer* 10: 22-44.
- Ramo, C., Busto, B. and Utrera, A. (1992). Breeding and rearing the Orinoco crocodile *Crocodylus intermedius* in Venezuela. *Biological Conservation* 60(2): 101-108.
- Targarona, R.R., Soberón, R.R., Tabet, M.A. and Thorbjarnarson, J.B. (2010). Cuban crocodile *Crocodylus rhombifer*. Pp 114-118 in *Crocodiles. Status Survey and Conservation Action Plan, Third Edition*, ed. by S.C. Manolis and C. Stevenson. Crocodile Specialist Group: Darwin.
- Thorbjarnarson, J.B. (1991). Ecology and Behavior of the Spectacled Caiman (*Caiman crocodilus*) in the Central Venezuelan Llanos. PhD thesis, University of Florida, Gainesville, FL, USA.
- Thorbjarnarson, J.B. and Hernández, G. (1993). Reproductive ecology of the Orinoco crocodile (*Crocodylus intermedius*) in Venezuela. I. Nesting ecology and egg and clutch relationships. *Journal of Herpetology* 27(4): 363-370.
- Trutnau, I. and Sommerlad, R. (2006). *Crocodylians. Their Natural History and Captive Husbandry*. Edition Chimaira:

Frankfurt am Main.

Verdade, L.M. (1992). Manejo reprodutivo do jacaré-de-papo-amarelo, *Caiman latirostris* (Daudin, 1802), em cativeiro. PhD thesis, Universidade de São Paulo, San Paulo, Brazil.

Vliet, K.A. (1989). Social displays of the American alligator (*Alligator mississippiensis*). American Zoologist 29(3): 1019-1031.

Webb, G.J.W. and Manolis, S.C. (1989). Crocodiles of Australia. Reed Books: Sydney.

Vliet, K.A. (2001). Courtship behaviour of American alligators *Alligator mississippiensis*. Crocodilian Biology and Evolution 1: 383-408.

Webb, G.J.W., Buckworth, R. and Manolis, S.C. (1982). *Crocodylus johnstoni* in a controlled environment chamber: A raising trial. Australian Wildlife Research 10: 301-305.

Webb, E.C., Veldsman, D.M., Myburgh, J.G. and Swan, G.E. (2021). Effects of stocking density on growth and skin quality of grower Nile crocodiles (*Crocodylus niloticus*). South African Journal of Animal Science 51(2): 142-150.

Widholzer, F.L., Borne, B. and Tesche, T. (1987). Breeding the broad-nosed caiman in captivity. International Zoo Yearbook 24/25: 226-230.

Wise, M. (1994). Techniques for the capture and restraint of captive crocodilians. Pp. 401-405 in Captive Management and Conservation of Amphibians and Reptiles, ed. by J.B. Murphy, K. Adler, and J.T. Collins. Society for the Study of Amphibians and Reptiles: Ithaca.

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FIRSTREFERENCEGENOMESFORTRUECROCODILES REVEAL CONTRASTING DEMOGRAPHIC HISTORIES AND CONSERVATION CONCERNS FOR THE ORINOCO CROCODILE. Genomic resources are becoming increasingly important for understanding the evolutionary history of vertebrates and guiding their conservation and management. However, until recently, no high-quality, long-read reference genome was available for any member of the family Crocodylidae. In a recent study, we generated the first reference-grade genomes for two species of ‘true’ crocodile: the Orinoco crocodile (*Crocodylus intermedius*) and the Nile crocodile (*C. niloticus*). Although the two genomes showed high structural conservation, their demographic histories revealed a striking contrast (Fig. 1).

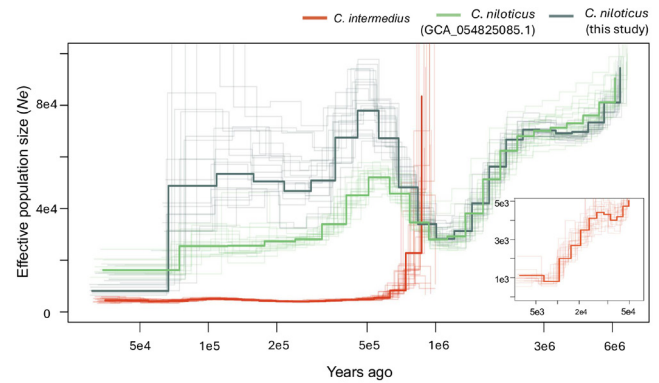


Figure 1. Demographic history for *Crocodylus intermedius* and *C. niloticus*. Inset panel shows a magnified view of the recent demographic trajectory of *C. intermedius*. From Saldarriaga-Gómez *et al.* (2026)

Crocodylus niloticus maintained relatively large effective population sizes (N_e) throughout much of its reconstructed history. In contrast, *C. intermedius* exhibited persistently small N_e throughout most of the late Quaternary. These results indicate that the current genetic vulnerability of the Orinoco crocodile cannot be understood solely because of the human-driven decline experienced during the twentieth century. Instead, *C. intermedius* appears to have persisted at relatively small N_e over long evolutionary timescales, likely exposing the species to prolonged genetic drift even before recent anthropogenic pressures. This historical pattern is consistent with recent population-level genetic studies reporting extremely low contemporary N_e in wild *C. intermedius* in Cravo Norte population in Colombia (Castillo *et al.* 2024).

By comparison, the Nile crocodile, which has a much broader geographic distribution across Africa, maintained N_e values an order of magnitude larger across several comparable periods. These contrasting trajectories demonstrate how the evolutionary and demographic histories of two crocodile species can differ and how those histories shape their present-day genetic condition.

For *C. intermedius*, these findings reinforce the need to incorporate genetic and evolutionary information into conservation planning. Because remaining wild populations are already small and fragmented, management decisions should consider not just the number of individuals present or released into the wild, but also the genetic diversity they carry. Captive breeding, reintroduction, translocation, and population reinforcement programs are opportunities to maintain and preserve remaining genetic variation and should therefore incorporate genetic criteria whenever possible (Fig. 2).

Beyond their immediate conservation implications, these first reference genomes for *Crocodylus* provide new resources for crocodilian research. They establish a genomic foundation for future studies on population structure, adaptation, structural variation, demographic history and change, and conservation genomics across the genus. For critically endangered species

like the Orinoco crocodile, reading and understanding the past through their genomes can help us make better-informed decisions about how to protect and manage the diversity that remains.



Figure 2. Orinoco crocodile (*Crocodylus intermedius*) at Estación de Biología Tropical Roberto Franco, Colombia. Photograph: Ana M. Saldarriaga-Gómez.

Literature Cited

Castillo-Rodríguez, N., Saldarriaga-Gómez, A.M., Antelo, R. and Vargas-Ramírez, M. (2024). First genetic evaluation of a wild population of *Crocodylus intermedius*: New insights for the recovery of a critically endangered species. PLoS ONE 19(10): e0311412.

Saldarriaga-Gómez, A.M., Luzuriaga-Neira, A., Vargas-Ramírez, M., Amato, G. and Hekkala, E. (2026). Genome evolution and long-term demographic history in true crocodiles. Genes, Genomes, Genetics 16(9): jkag178.

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Europe

France

SUCCESSFUL NATURAL OUTDOOR INCUBATION OF NILE CROCODILES (*CROCODYLUS NILOTICUS*) AT AN EXCEPTIONAL POLEWARD LATITUDE (44°N) IN SOUTHEASTERN FRANCE. Crocodilian reproduction is highly dependent on environmental conditions. Crocodilians can thermoregulate by moving between water and land, basking, seeking shade and selecting favorable microhabitats. Embryos remain confined to the nest site selected by the female, and nest temperature and moisture directly influence embryonic development, hatching success and offspring sex (Hutton 1987).

Female nest-site selection can partly modify these conditions. Solar exposure, vegetation, substrate, nest depth and proximity to water all influence the thermal and hydric environment experienced by developing eggs (Swanepoel *et al.* 2000; Combrink *et al.* 2017; Viljoen *et al.* 2025). The poleward distribution of crocodilian reproduction is consequently strongly constrained by climate, which applies in both hemispheres. Breeding populations of crocodilians in the wild occur to approximately 35°N for the American alligator (*Alligator mississippiensis*; Lance 2003), to 32°S for the Broad-snouted caiman (*Caiman latirostris*; Simoncini *et al.* 2009).

Against this background, the successful outdoor incubation of a Nile crocodile (*C. niloticus*) clutch at La Ferme aux Crocodiles, in Pierrelatte, southeastern France, at 44°21'N, represents an unusual reproductive event.

Study population and enclosure

La Ferme aux Crocodiles maintains a large adult population of *C. niloticus* within an enclosure of an area of 6000 m², of which 4500 m² is situated within/under a greenhouse, where environmental conditions are buffered from the external climate, and 1500 m² of which is outdoors, and thus exposed to prevailing natural climatic conditions. Crocodiles can move freely between both areas.

The breeding crocodile population comprises 257 adults: 7 males (3.8 to 4.5 m TL) and 250 females (2.2 to 3.0 m TL). Most animals are 35 years old and have been maintained at the facility since their importation from South Africa in 1991.

Most females nest within the greenhouse, but 10-15 females enter the outdoor area (Figs. 1 and 2) during the nesting season each year and excavate nests there. Outdoor nesting is therefore not considered exceptional. Rather, it appears to represent an opportunistic but regular component of reproductive behaviour within this large captive population.

Under normal husbandry practice, eggs are collected from nests and transferred to artificial incubators. However, some clutches remain uncollected. Historically, such “uncollected” clutches have generally failed to hatch, from both the greenhouse and outdoor areas.

The significance of the 2026 observation therefore lies not in the female nesting outdoors, but in successful completion of embryonic development under natural conditions.

The 2026 reproductive event

The exact date of egg-laying of the successful nest was not known, but other outdoor nests that were collected were laid around 15 May 2026. The nest was situated immediately adjacent to the outdoor pool in predominantly sandy substrate with sparse grass cover (Fig. 3). The egg chamber was estimated to have been approximately 30-40 cm below the substrate surface. The outdoor enclosure is principally exposed towards the southeast.



Figure 1. Outdoor Nile crocodile enclosure.



Figure 2. Outdoor Nile crocodile enclosure.

At approximately 1415 h on 22 August 2026, a female was observed actively excavating the nest, and carrying the first hatchlings towards the adjacent pool. This behaviour began spontaneously before any intervention by keepers for management and safety reasons. The outdoor enclosure was designed to contain adult crocodiles and could not reliably contain hatchlings, which could potentially pass through openings inaccessible to adults. The outdoor environment also exposed hatchlings to potential predation by wild birds.

The unhatched eggs remaining in the nest (N= 11) were removed during keeper intervention, and 7 of them hatched spontaneously within minutes (Fig. 4). The remaining four eggs were considered to be infertile. Twelve viable hatchlings were counted (5 had been already carried to the water by the female), indicating a clutch size of 16 eggs (75% hatching rate of all eggs, 100% hatching rate of viable eggs).

Keeper intervention therefore did not contribute to incubation. Embryonic development had occurred under natural outdoor conditions, hatching had already begun, and the female had initiated natural nest excavation and hatchling transport before intervention.

The maternal behaviour observed is consistent with that described with Nile crocodiles elsewhere. Crocodilian



Figure 3. Nesting area in outdoor Nile crocodile enclosure.



Figure 4. One of the Nile crocodile hatchlings emerging.

embryos produce hatching calls, and Caron-Delbosc *et al.* (2025) experimentally demonstrated that sustained calls from fully-developed *C. niloticus* embryos stimulate females to excavate their nests. Maternal attendance and hatchling liberation have also been documented in wild populations (Combrink *et al.* 2017).

Thermal significance of the event

Adult crocodilians can compensate behaviorally for environmental temperature by moving between water and land, basking, seeking shade and selecting favorable microhabitats. Eggs cannot relocate after oviposition, and so their thermal environment depends principally on nest depth, substrate characteristics, solar radiation, vegetation, rainfall, moisture and prevailing weather.

This event occurred during an exceptional climatic period in France. The summer of 2026 was the hottest recorded in the country since national meteorological records began in 1900. Of particular relevance to the final phase of incubation, France experienced a prolonged heatwave between 28 July and 19 August 2026 (Fig. 5). This 23-day event equaled the longest heatwave previously recorded in France and was characterized by persistent high temperatures in southeastern France and the Rhône Valley. The episode reached maximum intensity on 13-14 August, only 8-9 days before the hatchlings emerged at Pierrelatte on 22 August (Météo-France 2026).

Notwithstanding the unknown date of egg-laying, it is clear that the nest was 'exposed' to maximum ambient temperatures that exceeded 40°C on some days. However, this does not mean that the eggs reached such temperatures, as they are buffered by the nest substrate. The pattern of ambient temperatures resembles that of another hole-nesting species, *C. johnstoni*, where nest (egg) temperatures at time of laying are generally low, but increase over time until hatching (see Webb *et al.* 1983). The relatively high temperatures for the Pierrelatte nest occurred mainly in the latter part of incubation, where embryos would be likely to be able to withstand higher temperatures if exposed to them.

These exceptional conditions are potentially important for interpreting the successful incubation of this clutch.

Temperature strongly influences embryonic development in crocodilians. Hutton (1987) recorded incubation periods of approximately 110 days at constant 28°C and approximately 85 days at 34°C for *C. niloticus*. Natural nests also show substantial vertical and diel thermal variation, with shallower eggs generally experiencing warmer conditions and more rapid development. Had the nest been laid around the same date (15 May) as other nests in the outdoor area, incubation period would be calculated as 99 days, and indicating a mean nest temperature of around 31°C. Had the nest been laid one week earlier or one week later (8 May or 22 May), incubation periods of 106 and 92 days, respectively would indicate mean nest temperatures of around 29 and 32°C respectively.

The physical characteristics of the Pierrelatte nest may have interacted with the unusually warm summer conditions. The nest was constructed in predominantly sandy substrate with sparse vegetation and substantial solar exposure (Fig. 3). Burial at approximately 30-40 cm would have buffered the eggs from short-term surface temperature fluctuations while potentially allowing heat accumulated during prolonged warm periods to be retained within the substrate. The predominantly southeast-facing exposure may also have favoured solar heating, while proximity to the pool may have influenced substrate moisture and thermal stability.

The prolonged nature of the 2026 heatwave may be particularly relevant. Crocodilian embryonic development depends on the thermal conditions experienced throughout incubation, rather than on isolated maximum air temperatures. In *C. niloticus*, developmental rate increases with incubation temperature (Hutton 1987). The 23 consecutive days of heatwave conditions immediately preceding hatching may therefore have contributed substantially to maintaining a favorable thermal environment during the final phase of embryonic development. Interestingly, hatching was also observed the day after one of the very few rainstorms of the

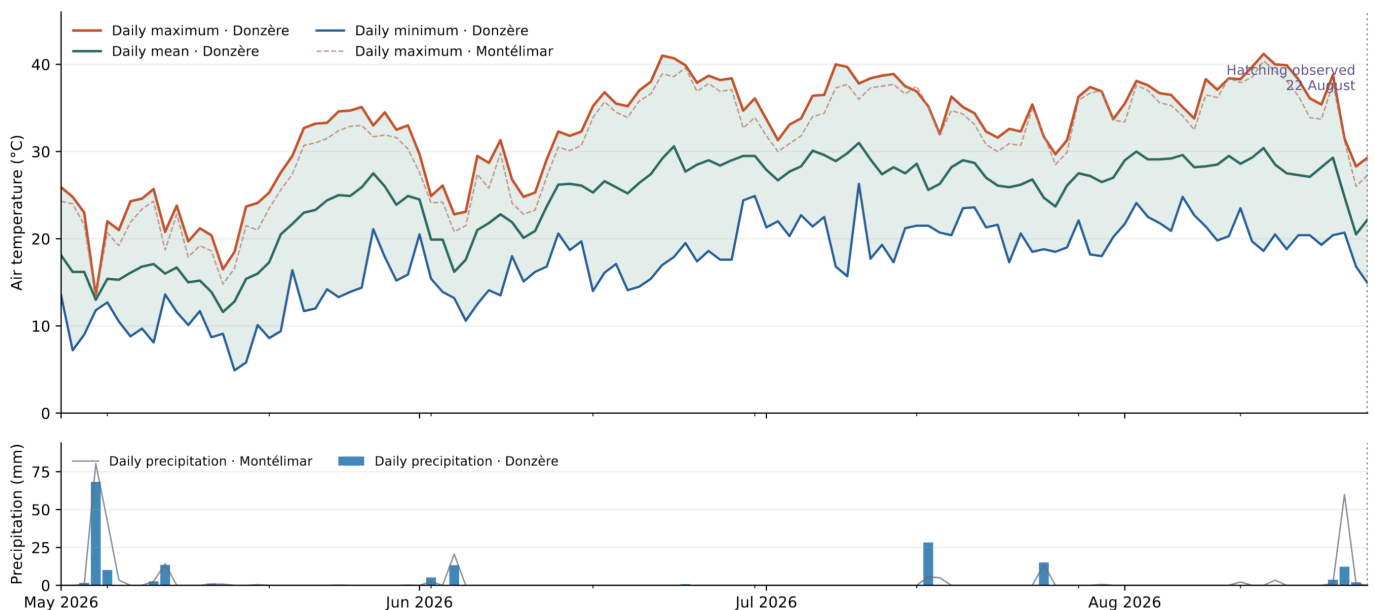


Figure 5. Daily minimum, maximum and mean ambient temperatures and rainfall at Donzère station (approx. 10 km north of Pierrelatte), 1 May to 22 August 2026. Daily maximum ambient temperature at Montélimar station (approx. 30 km north of Pierrelatte) is included for comparative purposes.

summer, suggesting that changes in nest moisture may also have played a role.

However, temperature and moisture were not measured within the nest during incubation, preventing a direct causal relationship from being established between these climatic events and successful hatching. Air temperature does not directly reflect nest temperature, which is also influenced by substrate depth, solar radiation, soil moisture and other local microclimatic conditions.

Given the exceptionally high latitude of the nest and the thermal requirements of *C. niloticus* embryogenesis, the prolonged heat experienced during summer 2026 was very likely an important component of the conditions that permitted successful incubation. A single successful clutch cannot demonstrate a causal relationship with long-term climate change. However, its occurrence during an exceptionally warm summer is consistent with the hypothesis that increasingly frequent and intense periods of extreme heat may create temporary climatic windows suitable for crocodilian embryonic development at latitudes where temperature would normally be limiting.

The 2026 event therefore supports a testable hypothesis: exceptional summer temperatures, combined with favorable nest characteristics, created a sufficiently warm and stable microclimate to allow *C. niloticus* embryos to complete development under outdoor conditions at Pierrelatte. Future monitoring of naturally incubated nests, combined with local meteorological data and direct measurements of nest temperature and moisture, should allow this hypothesis to be tested.

Northern and southern limits of crocodilian reproduction

When discussing climatic reproductive limits, absolute latitude is more informative than northern latitude alone, as crocodilian populations at both northern and southern range margins are exposed to increasingly seasonal and cooler climates. The northernmost well-documented breeding populations of extant crocodilians are those of *A. mississippiensis* in coastal North Carolina, at approximately 35°N. Lance (2003) described alligators as the most northerly distributed living crocodilians and reported reproducing populations at this latitude. Cold conditions impose major seasonal restrictions: feeding ceases below approximately 16°C and may remain suspended for 6 months or longer.

In the southern hemisphere, the Broad-snouted caiman (*Ca. latirostris*) provides an important comparison. The species has an exceptionally large latitudinal distribution, extending from approximately 5°S to 32°S (Simoncini *et al.* 2009). Natural nesting has been recorded as far south as El Rico Island, Santa Fe Province, Argentina (32°16'S, 60°40'W; Piña *et al.* 2002). Long-term studies in Santa Fe confirm reproduction in these southern populations, demonstrating that crocodilians can reproduce naturally under the strongly seasonal climatic conditions encountered above 30°S.

With *C. niloticus*, Lake St Lucia, KwaZulu-Natal, South Africa, at approximately 28°S, represents the southernmost established natural breeding population (Leslie and Spotila 2001). This population is particularly informative because it illustrates the importance of nest microclimate near a climatic range margin. Females predominantly use open, sunny nesting sites, and Leslie and Spotila (2001) found that shaded substrate could be approximately 5-6°C cooler than exposed sites at comparable depths. Shading could therefore reduce nest temperatures sufficiently to influence embryonic development and sex ratios. The Pierrelatte nest presents a notable parallel: it was also situated in sparsely vegetated, sandy substrate with considerable solar exposure.

Historical Nile crocodile records extend farther south than Lake St Lucia. Feely (2010) reviewed reliable records of crocodiles occurring as far south as approximately 32°18'S in the Eastern Cape. These records demonstrate occurrence, however, rather than an established breeding population at that latitude. The distinction between occurrence and reproduction is important, since adults may survive in environments where nest conditions are insufficient for successful embryogenesis.

The southern limit represented by *Ca. latirostris* is therefore a more appropriate southern hemisphere comparison when considering Crocodylia as a whole. At approximately 32°S, its documented natural nesting populations occur considerably farther from the equator than the southern breeding limit of *C. niloticus*, although still less poleward than the approximately 35°N reproductive limit of *A. mississippiensis*.

Pierrelatte, at 44.35°N, lies approximately 9° farther from the equator than the northernmost well-documented wild crocodilian reproduction and approximately 12° farther poleward than the southernmost documented natural nesting of *Ca. latirostris*. Thus, in terms of absolute latitude, the Pierrelatte clutch completed natural outdoor incubation substantially beyond the known latitudinal envelope of regular wild crocodilian reproduction.

This does not suggest that Nile crocodiles could establish a wild population in southeastern France. Winter survival, juvenile growth, feeding, maturation and repeated reproduction represent additional constraints. The observation demonstrates instead that a suitable summer nest microclimate can occur much farther poleward than the distribution of self-sustaining crocodilian populations.

A review of the available literature did not identify natural outdoor incubation at a comparable or greater absolute latitude in any extant crocodilian. For *C. niloticus*, a relevant captive comparison is provided by Crocoparc Agadir, Morocco, where Nile crocodiles reproduce outdoors (Caron-Delbosc *et al.* 2025). Agadir lies at approximately 30°N, whereas Pierrelatte lies at 44.35°N, approximately 14° farther north.

Crocodilians are maintained and bred in zoological institutions at considerably higher latitudes, particularly in Europe, but captive breeding records usually involve artificial incubation

or indoor, heated and climatically managed environments. Such records are therefore not directly comparable with complete embryonic development in an unheated outdoor substrate exposed exclusively to natural climatic conditions.

The Pierrelatte event is consequently remarkable not only within the reproductive biology of *C. niloticus*, but also in the broader context of living Crocodylia. Based on the scientific literature identified to date, we are unaware of any other documented case of *C. niloticus* completing natural outdoor incubation at a latitude equivalent to or higher than Pierrelatte. We therefore consider the 2026 event to represent, to our knowledge, the northernmost documented successful natural outdoor incubation of *C. niloticus*. It may also represent the most poleward documented case of complete natural outdoor incubation among extant crocodilians; however, confirmation of such a broader record would require a systematic review of zoological breeding records and unpublished institutional data.

Future monitoring

The annual occurrence of approximately 10-15 outdoor nesting females creates an opportunity to investigate this event prospectively. Future monitoring should compare outdoor nests left under natural conditions, greenhouse nests left *in situ* and artificially incubated clutches.

Temperature loggers should be placed at several levels within or immediately adjacent to nests, ideally recording every 10-15 minutes. Additional loggers in nearby unused substrate would provide controls. Equivalent measurements inside the greenhouse would allow comparison between both environments. Substrate moisture, nest depth, vegetation, solar exposure, shading, orientation and distance from water should also be recorded.

For each clutch, data should include laying date, clutch size, fertility, hatching success, incubation duration, embryonic mortality and developmental stage of unhatched embryos. Hatchlings should be measured and weighed using standardized protocols. Sex ratio would be particularly informative because *C. niloticus* exhibits temperature-dependent sex determination (Hutton 1987).

Failed nests are as important as successful nests. Determining whether embryos die early or late in development could help distinguish insufficient accumulated heat from other causes of reproductive failure.

The Pierrelatte population therefore provides an unusual opportunity to investigate how weather, nest-site characteristics and maternal nest selection interact at the thermal limits of crocodilian embryonic development. Long-term monitoring may reveal whether the 2026 event was an exceptional occurrence or an early indication that increasingly warm summers are expanding the frequency of temporary reproductive opportunities at unusually high latitudes.

Literature Cited

- Caron-Delbosc, N., Boyer, N., Mathevon, N. and Grimault, N. (2025). Crocodile mothers' response to hatching calls. *Animal Behaviour* 220: 123040.
- Combrink, X., Warner, J.K. and Downs, C.T. (2017). Nest-site selection, nesting behaviour and spatial ecology of female Nile crocodiles *Crocodylus niloticus* in South Africa. *Behavioural Processes* 135: 101-112.
- Dunham, K., Dinkelacker, S. and Miller, J. (2014). A stage-based population model for American alligators in northern latitudes. *The Journal of Wildlife Management* 78: 440-447.
- Feely, J.M. (2010). On the southeastern range limits of the Nile crocodile: A review of its past and present occurrences in the Eastern Cape and Western Cape, South Africa. *South African Journal of Wildlife Research* 40: 169-175.
- Gardner, B., Garner, L.A., Cobb, D.T. and Moorman, C.E. (2016). Factors affecting occupancy and abundance of American alligators at the northern extent of their range. *Journal of Herpetology* 50: 541-547.
- Hutton, J.M. (1987). Incubation temperatures, sex ratios and sex determination in a population of Nile crocodiles *Crocodylus niloticus*. *Journal of Zoology* 211: 143-155.
- Lance, V.A. (2003). Alligator physiology and life history: The importance of temperature. *Experimental Gerontology* 38: 801-805.
- Leslie, A.J. and Spotila, J.R. (2001). Alien plant threatens Nile crocodile *Crocodylus niloticus* breeding in Lake St Lucia, South Africa. *Biological Conservation* 98: 347-355.
- Mazzotti, F.J., Balaguera-Reina, S.A., Brandt, L.A., Briggs-González, V., Cherkiss, M.S., Farris, S.C. and Godahewa, A. (2022). Natural and anthropogenic factors influencing nesting ecology of the American crocodile in Florida, United States. *Frontiers in Ecology and Evolution* 10: 904576.
- Météo-France (2026). Retour sur la 3e vague de chaleur de l'été du 28 juillet au 19 août 2026. Météo-France. Accessed 6 September 2026.
- Simoncini, M.S., Piña, C.I. and Siroski, P.A. (2009). Clutch size of *Caiman latirostris* (Crocodylia: Alligatoridae) varies on a latitudinal gradient. *North-Western Journal of Zoology* 5: 191-196.
- Swanepoel, D.G.J., Ferguson, N.S. and Perrin, M.R. (2000). Nesting ecology of Nile crocodiles *Crocodylus niloticus* in the Olifants River, Kruger National Park. *Koedoe* 43: 35-46.
- Thorbjarnarson, J., Wang, X., Shao, M., He, L., Ding, Y.,

Wu, Y. and McMurtry, S.T. (2002). Wild populations of the Chinese alligator approach extinction. *Biological Conservation* 103: 93-102.

Viljoen, D.M., Webb, E.C., Myburgh, J.G., Truter, J.C., Van Wyk, H. and Myburgh, A. (2025). Thermal profiles associated with nest site selection of Nile crocodiles *Crocodylus niloticus* on a commercial crocodile farm. *Journal of Thermal Biology* 131: 104179.

Webb, G.J.W., Buckworth, R. and Manolis, S.C. (1983). *Crocodylus johnstoni* in the McKinlay River area, N.T. VI. Nesting biology. *Australian Wildlife Research* 10: 607-637.

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South Asia & Iran

India

THE POSSIBLE INFLUENCE OF PHYSICAL AND BEHAVIOURAL ATTRIBUTES IN THE DEVISING OF AN OLD SLANG NAME FOR *GAVIALIS GANGETICUS*. The Gharial (*Gavialis gangeticus*), one of the most easily identifiable members of the Crocodylia, has been referred to with a variety of scientific names and a likewise diverse litany of common names. Review of publications dating from the mid-19th century and into the early 20th century finds a slang term that is not seen in more recent examinations, popular or scientific: “nakoo” or “nako”. The word was seldom explained when used, and yet examination of the term provides insights into the possible role of both physical and behavioural observations in the formation of the local colloquialism.

Nakoo

A wide variety of popular and professional publications of the period noted use of the term “nakoo” in India to refer to the Gharial (Wood 1855, 1863; Günther 1864; Ogilvie and Annandale 1883; Goodrich *et al.* 1885; Skeat 1887; Kingsley 1888; Pierce 1910; Duncan 1890; Anon 1926). As referenced at the time, the term was exclusive to the Gharial and not used to refer to the Mugger crocodile (*Crocodylus palustris*), with which it is sympatric.

Based on consulted dictionaries of the time, the term was pronounced as nah-koo, but no publication provided a source language or even meaning beyond its use as an alternative name for the Gharial. This information was likely lost as works published during this period often contained unattributed material from other sources, which resulted in terminology becoming widespread and imparted with an essence of validity as more works used it, but the lack of sourcing left us with a feral factoid.

An article appearing in a non-scientific periodical provides a clue. Francis (1891) writes that: “The mugger or nakoo (*Crocodylus palustris*) has a short, broad snout, with a large protuberance where the nostrils are, hence its name of Nakoo or ‘Nosey’”. While the passage clearly confuses the Mugger and Gharial, the linkage to a meaning was critical in identifying the language as Bengali or Bangla. Modern renderings of the term spell it as nāku and as an adjective it means “given to speaking through one’s nose; spoken through the nose; long-nosed, nosy” (Biswas 2000). It should also be noted that in Ruskin Bond’s children’s book “Cricket for the Crocodile”, the animal in question is referred to as Nakoo and notes it means “nosey”, but the crocodile in question is a Mugger and not a Gharial (Bond 1986).

Physical and behavioural implications

While initial motives for referring to a Gharial as ‘nosey’ may be clear, the use of the term may evidence a deeper understanding of the animal based on observations of its physical and behavioural characteristics.

The characteristic long, very narrow snout of the Gharial is implicated in the meaning of ‘long-nosed’, especially in comparison to the broad, rugose snout of *C. palustris*. However, it may be the ghara of mature male Gharials that offers additional sources of inspiration for the use of nāku. The ghara is an intriguing structure, with Stevenson and Whitaker (2010) noting that, “Although the function of the ‘ghara’ is not well understood, it is apparently used as a visual sex indicator, as a sound resonator, or for bubbling or other associated sexual behaviours”.

The appearance and size of the ghara make it visually distinctive not only for the Gharial themselves but also for humans. Such a structure meets an understanding of ‘nosey’. The more interesting element is the other meaning of “given to speaking through one’s nose” (Biswas 2000). The role of the ghara in producing noises including hisses and other controlled bursts of air through the nostrils was identified in several early studies (Acharjyo *et al.* 1975; Biswas *et al.* 1977; Martin and Bellairs 1977). It is also possible the “pop” sounds made by Gharials (Jailabdeen *et al.* 2018; Bourke *et al.* 2021; Ajji M 2025) are part of the cacophony inspiring the observation, yet it is more likely the air expressed through the ghara and any potential associated water spray from the air movement is the inspiring behaviour for the term.

The use of nāku evidences how detailed observation by local people of physical and behavioural characteristics of an animal, such as the Gharial, can facilitate the creation of a descriptive and widely understood slang name unique to that species and should not be taken for granted when exploring the natural history of any species.

Literature Cited

Acharjyo, L.N., Biswas, S. and Misra, R. (1975). Some notes on gharial (*Gavialis gangeticus* (Gmelin)) in captivity. *Journal of the Bombay Natural History Society* 72(2): 558-

- Ajji M., J. and Lang, J.W. (2025). Gharial acoustic signaling: Novel underwater pops are temporally based, context-dependent, seasonally stable, male-specific, and individually distinctive. *Journal of Anatomy* 246: 415-443.
- Biswas, S. (2000). *Bengali-English Dictionary*. Sahitya Samsad: Calcutta.
- Biswas, S., Acharjyo, L.N. and Mohapatra, S. (1977). A note on the protuberance or knob on the snout of male gharial, *Gavialis gangeticus* (Gmelin). *Journal of the Bombay Natural History Society* 74(3): 536-537.
- Bond, R. (1986). *Cricket for the Crocodile*. MacRae: London.
- Bourke J., Fontenot N. and Holliday C. (2021). Septal deviation in the nose of the longest faced crocodylian: A description of nasal anatomy and airflow in the Indian gharial (*Gavialis gangeticus*) with comments on acoustics. *The Anatomical Record* 305(10): 1-21.
- Duncan, P. (1890). *Cassell's Natural History*. Cassell, Petter, Galpin & Company: London.
- Francis, T. (1891). In the Jaws of an Alligator. *The Boy's Own Annual* 14: 248-250.
- Goodrich, S., Winchell, A., Youmans, E., Seelye, J. and Tenney, S. (1885). *Johnson's Natural History, Comprehensive, Scientific, and Popular, Illustrating and Describing the Animal*. W.B. Stickney: Concord.
- Günther, A. (1864). *The Reptiles of British India*. Robert Hardwicke: London.
- Jailabdeen, A., Lang, J.W., Singh, R.K. and Archunan, G. (2018) Gharial communication: acoustic signaling via "pops". Pp. 41-46 in *Proceedings of WESPAC 2018: 13th Western Pacific Conference on Acoustics*, New Delhi, India, 11-15 November 2018.
- Kingsley, J. (1888). *The Riverside Natural History*, Vol. 3, Parts 97-102. Kegan Paul Trench and Co.: London.
- Martin, B. and Bellairs, A. (1977). The narial excrescence and pterygoid bulla of the gharial *Gavialis gangeticus* (Crocodylia). *Journal of Zoology* 182(4): 541-558.
- Ogilvie, J. and Annandale, C. (1883). *The Imperial Dictionary of the English Language*. Blackie and Sons: London.
- Pierce, R. (1910). *Dictionary of Hard Words*. Dodd Mead and Company: New York.
- Skeat, W. (1887). Notes on English Etymology. *Transactions of the Philological Society* 27: 283-333.
- Stevenson, C. and Whitaker, R. (2010). *Indian Gharial Gavialis gangeticus*. Pp. 139-143 in *Crocodiles. Status Survey and Conservation Action Plan, Third Edition*, ed. by S.C. Manolis and C. Stevenson. Crocodile Specialist Group: Darwin.
- Anon. (1926). Baby alligators astray in northern rivers. *Literary Digest* 91(11): 68-72.
- Wood, J. (1855). *The New Illustrated Natural History*. Routledge: London.
- Wood, J. (1863). *Natural History Picture Book for Children*. Routledge: London.
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General

UNPACKING A NEW DEFINITION OF HUMAN-WILDLIFE COEXISTENCE FOR CROCODYLIANS. In April 2026, the Defining Coexistence Working Group of the IUCN SSC Human-Wildlife Conflict & Coexistence Specialist Group (HWCCSG) published a definition of human-wildlife coexistence. Although "coexistence" is now in the mainstream of conservation science discussions of human-wildlife interactions, so many frameworks and definitions have been offered that uncertainty exists over what the concept means and how to operationalise it. Therefore, this definition and its supporting document on key dimensions of coexistence (HWCCSG 2026) was developed over two years, with input from a series of workshops, to provide a more coherent basis for developing visions for coexistence in particular contexts.

This article outlines the key dimensions of coexistence that emerged from this process, for the information of crocodilian managers, conservationists, researchers, etc. Despite the scepticism from some quarters on whether it is possible to coexist with crocodilians - often popularly considered to be universally aggressive, primitive animals of low intelligence incapable of learning and adapting to sharing habitats and resources with their fellow creatures - I believe it is possible to coexist with crocodilians, despite the real and terrible damage they are capable of inflicting on humans and their domesticated animals (Pooley 2023).

Definition and dimensions of coexistence

The published definition is worded as follows: "Human-wildlife coexistence is a dynamic state in which humans and wildlife co-occur in resilient communities and ecologically viable populations, sustained in socially acceptable ways through just institutions and fair processes that enable co-adaptation, adaptive management, and negotiated solutions to keep negative impacts or conflicts at acceptable levels" (IUCN SSC HWCCSG 2026).

This definition conceives of coexistence as an ongoing,

constantly negotiated state, which will always be disrupted on occasion by negative interactions such as attacks or persecution of crocodilians, and disturbed by conflicts between human interest groups over how to deal with these. Coexistence does not imply an absence of conflict. As the IUCN document (IUCN SSC HWCCSG 2026) states: “The commitment is to work to sustain an ongoing state of coexistence through accepted processes and interventions for dealing with these.” Where there are ongoing negative interactions, the challenge is to maintain levels of conflict and impacts within acceptable limits. Of course, this requires consideration of the experiences and capacities of everyone impacted by such negative interactions (acceptable to whom?).

It is a normative aspiration of the authors of the IUCN definition that coexistence (unlike tolerance or acceptance) should be a free choice of those communities sharing landscapes with crocodilians. Not every individual will agree with such choices to coexist, but if the impacted communities are involved and represented in equitable ways, then that works.

This recognises that different communities experience crocodilians, and conservation efforts to protect them, in very different ways, and have unequal capacities to influence decisions about crocodilian management. Supporting (or fostering) coexistence requires ongoing negotiations over responsibilities, rights and trade-offs within unequal power relations (Guibrune *et al.* 2021; Hsiao *et al.* 2023).

For existing human-wildlife relationships in a landscape to be called coexistence, they must endure in a situation of successful long-term co-occupation of that landscape. This usually requires persisting at different spatial scales, negotiating local factors like livelihoods activities like fishing or washing that bring humans into contact with crocodilians, but also national, regional and global policy and governance frameworks (eg regional management protocols, national development plans impacting on wetlands, CITES).

Coexistence also requires maintaining ecological connectivity, and at larger than local scale, the distributions of crocodilians may extend across areas where coexistence states and processes vary in intensity (a particular challenge where crocodilians migrate seasonally). For example, Mugger crocodiles inhabit the wetlands of Central Gujarat, where some communities in Anand and Kheda coexist with them, but in neighbouring parts of Vadodara there is conflict and intolerance (Pooley *et al.* 2021). Coexistence with crocodilians, in other words, may exist across a range of tolerances (weak to strong), in terms of what levels of presence or impacts communities feel willing to live with. Coexistence as a concept, therefore, embraces a diversity of management approaches across landscapes, provided that the fundamental ecological and social needs of both wildlife and humans are maintained.

Given that human-wildlife coexistence occurs in context-specific ways in particular places, the IUCN coexistence

definition is offered as a basis and point of departure for specific communities to craft their own specific visions of coexistence, and related institutional processes, policies and management plans.

Governance and social justice

In contrast to tolerance, which may be imposed, consultations informing the development of the HWCCSG definition revealed a strong concern that governance institutions facilitating coexistence should be seen as legitimate and representative by those affected by them. What is challenging is that what is regarded as legitimate is context-specific too, as are norms for what constitutes adequate and fair representation. This may be a particular challenge for conservationists working with informal institutions for dealing with human-wildlife interactions. What a biology graduate from the USA or Europe working for an international NGO considers appropriate representation in community forums and governance processes, may be very different from what a community in Amazonia, Benin, Timor Leste or Lake Kariba in Zimbabwe thinks about this.

Fostering or supporting coexistence requires conservationists to understand and integrate different ways of thinking about society and its governance, and work through the existing institutional models and processes where coexistence exists already. There are some good examples of this in crocodilian conservation (eg East Timor; Brackhane *et al.* 2019). It is worth clarifying the difference between supporting coexistence where it exists already (eg Vyas 2023; Van der Ploeg 2023), and where, dependent on traditional beliefs, it is often being eroded, (eg Gonzales Jr *et al.* 2013), and fostering coexistence where the conditions seem right for it to exist (Skupien *et al.* 2016).

Of course, it is challenging to ensure that processes for planning and implementing relevant conservation measures adequately involve differently positioned groups within, as well as between, communities (eg women, youth, local conservation NGOs, fisherfolk, livestock farmers, hunters, seasonal resource users), not to mention different sectors in the local community, from fishing to farming and tourism.

These different sets of people may have fundamentally different worldviews, and relationships with wildlife, shaped by distinct cultural, historical, and place-based contexts (Athreya *et al.* 2023; Brackhane *et al.* 2019; Hill *et al.* 2023). Taking these into account requires input from social sciences including anthropology, environmental geography and political ecology. These fields consider how landscapes are shaped by unequal power relations, changing livelihoods and land use, histories of dispossession (including colonial), migrations, and development and extractive pressures like mining which have local impacts but are driven by global forces and actors (Lécuyer *et al.* 2024; Moon 2025). Crocodilian studies revealing the importance of cultural beliefs include: Van der Ploeg and Van Weerd’s work in the Philippines (Van der Ploeg *et al.* 2011; Van Weerd *et al.* 2023); Sideleau’s (2024) examination of the links between

smartphones, tin mining and crocodiles, on human-crocodile relations in the Bangka-Belitung islands, off the southeastern coast of Sumatra; and, Pooley (2013, 2025) has revealed how shifting perceptions of crocodiles and development over time have impacted on human-crocodile interactions in KwaZulu-Natal Province, South Africa. There is, in short, much to learn from cultural, economic and historical studies about the origins and ongoing challenges of coexisting with crocodilians in specific places.

In summary, coexistence with crocodilians requires just institutions to oversee fair processes for resolving disputes arising from the negative impacts of crocodilians, conflicts over how to respond to these, and the distribution of costs and benefits arising from the presence of crocodilians. Fostering coexistence requires attention to accountability mechanisms, the distribution of decision-making authority, institutional design, and representation (Sandström and Hsiao 2023).

Crocodilians

A coexistence perspective requires going beyond seeing crocodilians only as objects of management. Instead, they could be understood as active participants in more-than-human communities, whose behaviour influences ecological and social outcomes (Saunders and Jukes 2025). While humans are the responsible decision makers, acknowledging crocodilians' agency encourages more attention to their (and our) capacities for adaptation, learning and reciprocal interactions in shared landscapes. It also reminds us of our ethical responsibilities when managing and interacting with them. It may be helpful to think about multi-species communities, ecologically and socially, and consider relational ways of valuing nature and wildlife alongside the intrinsic or utilitarian valuations of traditional conservation (Culos *et al.* 2025; Keul 2013; Pooley *et al.* 2021).

Ecologically, wildlife have intrinsic constraints to their survival that cannot be negotiated, such as habitat requirements, and how much disturbance they can tolerate. Just surviving is not thriving, and the size of populations allowed to survive must be sufficient to sustain demographic and genetic viability. The conservation goal for human-crocodilian coexistence is to foster or support more than the basic survival of crocodilians in the places they share with humans: the goal is to achieve their mutual thriving. This will clearly not be possible everywhere. Currently, there are few signs that coexistence will occur any time soon in Sabah, Malaysia, for example. On the other hand, despite recent attacks and high-profile concern over the possible impacts on tourism at Puerto Vallarta, Mexico, it seems that coexistence may be replacing conflict as the main framing of human-crocodilian interactions in Mexico (P. Ponce-Campos and L. Sigler, pers. comm. 2026).

Management

Coexistence requires a management approach adapted to contexts where there is conflict, change, uncertainty and periodic perturbations. Adaptive co-management takes a

learning-by-doing approach, shaped by iterative learning and participative knowledge generation, making adjustments as necessary. It includes the relevant communities and groups involved and affected from inception and throughout the process. How plans are implemented, the tools used, and indicators and results of monitoring should be generally understood and accepted.

Information gathered and subsequent evaluation and decision making should similarly include representatives of those impacted (Armitage *et al.* 2009; Chakanyuka and Utete 2022).

Policy challenges

It is easier, and much more established within conservation, to measure negative impacts like attacks and the killing of crocodilians, than coexistence. To include coexistence into current policy frameworks like Target 4 of the Kunming-Montreal Global Biodiversity Framework would require some kind of metrics for coexistence. While indicators may prove useful, and assist monitoring of coexistence, ultimately coexistence depends on institutions that can manage uncertainty, deal with competing values and inequalities, and remain legitimate over time. They also need the protocols, resources and training to do so.

It is therefore likely better in the first instance to assess the presence of such institutions, and where necessary, establish or further support them, develop the necessary legal instruments and processes, policy frameworks, and management protocols and resources. The adaptive capacity (or resilience) of communities living with crocodilians is also important to assess, and work to support Cavalier *et al.* (2021). In short, to create the governance arrangements and capabilities required for facilitating or sustaining coexistence should be the first priority, and work on metrics for coexistence, come later.

Conclusion

A state of human-crocodilian coexistence is neither about the absence of conflict, nor can it ever be a fixed end-state. Instead, coexisting with crocodilians will be an ongoing societal process facilitated by just and adequately resourced institutions, inclusive practices and relationships that enable people and crocodilians to share landscapes under changing ecological and social conditions. The IUCN definition of coexistence provides a foundation for future research, policy development and management action - while acknowledging that coexistence is always context-dependent, contested and subject to negotiation.

Before concluding, it is important to recognise that the knowledge, values and belief systems of indigenous and local communities living with wildlife, have still to be integrated into this definition, and will require full engagement to achieve particular visions for coexistence in particular places. There is, in places, much to learn from communities that have developed practices and institutions that allow coexistence with crocodilians, whether that be through spiritual beliefs

and practices, education and outreach, social commitments to conservation, practical safety measures, sustainable use, or other means.

Next steps should involve engaging with these coexistence traditions to shape future thinking, inform governance principles and suggest alternative ways of relating to crocodilians. In crocodilian conservation studies, we really need transdisciplinary fieldwork on coexistence case studies to help us develop, test and refine our approaches to coexisting with crocodilians.

Literature Cited

- Armitage, D.R., Plummer, R., Berkes, F., Arthur, R.I., Charles, A.T., Davidson-Hunt, I.J., Diduck, A.P., Doubleday, N.C., Johnson, D.S., Marschke, M. and McConney, P. (2009). Adaptive co-management for social-ecological complexity. *Frontiers in Ecology and the Environment* 7: 95-102.
- Athreya, V., Dhee, Linnell, J.D.C., Nijawan, S. and Young, J. (2023). Traditional ecological knowledge. Pp. 94-97 in *IUCN SSC Guidelines on Human-Wildlife Conflict and Coexistence*. IUCN: Gland, Switzerland.
- Brackhane, S., Webb, G., Xavier, F.M.E., Trindade, J., Gusmao, M. and Pechacek, P. (2019). Crocodile management in Timor-Leste: Drawing upon traditional ecological knowledge and cultural beliefs. *Human Dimensions of Wildlife* 24(4): 314-331.
- Cavalier, R., Pratt, E.N., Serenari, C. and Rubino, E.C. (2022). Human dimensions of crocodilians: A review of the drivers of coexistence. *Human Dimensions of Wildlife* 27(4): 380-396.
- Chakanyuka, T. and Utete, B. (2022). Adaptive co-management, co-existence or just wildlife conservation? Case study of the human and Nile crocodile (*Crocodylus niloticus*) conflicts in Ngezi Dam, Mashonaland West, Zimbabwe. *African Journal of Ecology* 60: 759-768.
- Culos, M., Ouvrier, A. and Vimal, R. (2025). Thinking coexistence in human-dominated landscapes with the lens of multi-species assemblages: Farmers, brown bears and other wild species in the Pyrenees. *Biological Conservation* 302: 111006.
- Gonzales, Jr., M., Manalo, R.I., Alibo, V.L.B., Mercado, V.P., Belo, W.T. and Barlis, D.C. (2013). Manobo-Crocodile coexistence in Agusan Marsh, Philippines: A cultural legacy of mutual benefit. Pp. 83-89 in *Crocodiles*. Proceedings of the 22nd Working Meeting of the IUCN-SSC Crocodile Specialist Group. IUCN: Gland, Switzerland.
- Guibrunet, L., Gerritsen, P.R.W., Sierra-Huelsz, J.A., Flores-Díaz, A.C., García-Frapolli, E., García-Serrano, E., Pascual, U. and Balvanera, P. (2021). Beyond participation: How to achieve the recognition of local communities' value-systems in conservation? Some insights from Mexico. *People and Nature* 3: 528-541.
- Hill, C., Athreya, V., Glikman, J.A., Linnell, J.D.C. and Pooley, S. (2023). Culture and wildlife. Pp. 62-67 in *IUCN SSC Guidelines on Human-Wildlife Conflict and Coexistence*. IUCN: Gland, Switzerland.
- Hsiao, E., Margues, J. and Massé, F. (2023). Political ecology of wildlife. Pp. 147-151 in *IUCN SSC Guidelines on Human-Wildlife Conflict and Coexistence*. IUCN: Gland, Switzerland.
- IUCN (2023). *IUCN SSC Guidelines on Human-Wildlife Conflict and Coexistence*, First edition. IUCN: Gland, Switzerland.
- IUCN SSC HWCCSG (2026). What is human-wildlife coexistence? [Briefing Paper](#), IUCN SSC Human-Wildlife Conflict & Coexistence Specialist Group.
- Keul, A. (2013). Embodied encounters between humans and gators. *Social & Cultural Geography* 14(8): 930-953.
- Knox, J., Ruppert, K., Frank, B., Sponarski, C.C. and Glikman, J.A. (2021). Usage, definition, and measurement of coexistence, tolerance and acceptance in wildlife conservation research in Africa. *Ambio* 50: 301-313.
- Lécuyer, L., Balian, E., Butler, J.R.A., Barnaud, C., Calla, S., Locatelli, B., Newig, J., Pettit, J., Pound, D., Quétier, F. and Salvatori, V. (2024). The importance of understanding the multiple dimensions of power in stakeholder participation for effective biodiversity conservation. *People and Nature* 6: 1407-1420.
- Moon, K., (2025). Naming it is not enough: An orienting map for understanding conservation's entanglement with power. *Conservation Letters* 18: p.e13146.
- Pooley, S. (2013). No tears for the crocodiles: Representations of Nile crocodiles, and the extermination future in Zululand, South Africa, from 1956-58. Pp. 142-162 in *Wild Things: Nature and the Social Imagination*, ed. by W. Beinart, K. Middleton and S. Pooley. White Horse Press: Cambridge.
- Pooley, S. (2023). Introduction. *Current Conservation* (Special Issue: Coexisting with Reptiles) 17(4): 3-7.
- Pooley, S. (2025). Historical context of research in Maputaland, South Africa, and research in Ndumo Game Reserve to c.1988. [African Journal of Wildlife Research](#) 55.
- Pooley, S., Bhatia, S. and Vasava, A. (2021). Rethinking the study of human-wildlife coexistence. *Conservation Biology* 35: 784-793.
- Pooley, S., Hill, C. and Linnell, J.D.C. (2023). How histories

shape interactions. Pp. 68-73 in IUCN SSC Guidelines on Human-Wildlife Conflict and Coexistence. IUCN: Gland, Switzerland.

Skupien, G.M., Andrews, K.M. and Larson, L.R. (2016). Teaching tolerance? Effects of conservation education programs on wildlife acceptance capacity for the American alligator. *Human Dimensions of Wildlife* 21(3): 264-279.

Van der Ploeg, J. (2023). Human-crocodile coexistence in the Solomon Islands. *Current Conservation (Special Issue: Coexisting with Reptiles)* 17(4): 25-29.

Van Weerd, M., Cureg, M., Balbas, M. and Van der Ploeg, J. (2023). Culture, pride and coexistence with the Philippine crocodile. *Current Conservation (Special Issue: Coexisting with Reptiles)* 17(4): 30-35.

Vyas, R. (2023). Urban crocs: The case of muggers in Vadodara. *Current Conservation (Special Issue: Coexisting with Reptiles)* 17(4): 11-14.

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Recent Publications

Seymour, R.S., Miller, C.V., Hu, Q., Ezcurra, M.D., Nesbitt, S.J., Jones, M.E.H., Maidment, S.C.R., Schwarz, D., Wilberg, E.W., Campione, N.E. and Grigg, G. (2026). Blood flow rates to long bones of archosaurs reveal high aerobic metabolic rates and endothermy throughout most of their evolutionary history. [Paleobiology](#).

Abstract: The origin and evolution of endothermy among Archosauria are uncertain because living species are represented by two lineages: ectothermic crocodylians (Pseudosuchia) and endothermic birds (Aves). Endothermy is characterized by high metabolic rates (tachymetabolism) and a physiological ability to control body temperature (thermoregulation), partly by using heat generated within the body. Ectothermy is characterized by low metabolic rates (bradymetabolism) and behavioral body temperature regulation. Levels of metabolic rate can be indirectly assessed by measuring the size of primary nutrient foramina of long bones. Foramen radius is related to blood flow rate (Q) into the bone, which supports growth, repair, and remodeling of bone tissue that increase in more active vertebrates. Extant endothermic mammals are known to have profoundly higher Q than extant ectothermic reptiles of the same body size. This study measures nutrient foramina minor radius, mid-shaft circumference, and length of femora of archosaur fossils, focusing on the earliest lineages. It reports Q and body mass for 81 extinct archosauriform taxa and compares the data allometrically with extant endothermic and ectothermic vertebrates. The extinct archosauriforms yield generally higher Q values than occur in extant mammals and non-varanid reptiles. The study indicates that tachymetabolic archosauriforms dominated the Mesozoic from the Triassic onward. Their high basal metabolic rates produced heat potentially used for thermoregulation. With few exceptions, both Pseudosuchia and Aves exhibit high Q values from the Triassic to the Cretaceous. Aves apparently

remained endothermic until the present, while some tachymetabolic pseudosuchians became bradymetabolic relatively recently, as evident in extant crown crocodylians.

Non-technical Summary: Birds are active animals, with high and constant body temperatures. Their flight power relies on a high metabolism and a continuous supply of oxygen delivered to their cells. By contrast, crocodiles are generally slow-moving, with variable body temperatures and low metabolism. They can engage in powerful activity when capturing and drowning prey animals, and they can do it without breathing or relying on blood flow to supply oxygen. So, crocodiles can only engage in powerful activity for a short time before becoming exhausted. Because of these traits, birds are described as “warm-blooded” (endothermic), and crocodiles are described as “cold-blooded” (ectothermic). Both birds and crocodiles had a common ancestor approximately 250 million years ago. Once thought to be cold-blooded, this ancestor is now considered to have been more like a bird than a crocodile. This study traces the metabolism of the bird and crocodile lineages by measuring the size of holes in fossil leg bones called nutrient foramina. The holes contained arteries and veins to transport blood in and out of the bone. More active animals require more blood to grow and repair their bones, so they have larger holes. Today, “warm-blooded” birds and mammals have large holes, but “cold-blooded” crocodiles, lizards, and turtles have small ones. Our study of 81 different species of extinct bird and crocodile relatives confirms that the Triassic ancestors of dinosaurs (including birds) and crocodiles had high metabolic rates. Members of both groups were similar until recently, when crocodiles eventually became sit-and-wait predators in water, a lifestyle better suited to low metabolic rate, because they can hold their breath for long periods while waiting for prey and drowning it.

Mohammadzadeh, P., Bahrami, M.R.S., Mohammadi, S., Karimi, Z. and Tahmasbipour, N. (2026). Fatal visceral gout in three crocodylian species (*Crocodylus palustris*, *Caiman yacare*, and *Crocodylus suchus*): A multi-omics cohort study revealing purine metabolic collapse and mitochondrial injury. [Research Square](#).

Abstract: Visceral gout is a fatal metabolic disorder in captive crocodylians, yet its molecular pathogenesis remains poorly understood. This cohort study integrates clinical, pathologic, quantitative proteomic, targeted metabolomic, and transmission electron microscopic findings from 18 crocodylians (*Crocodylus palustris* n=9, *Caiman yacare* n=3, *Crocodylus suchus* n=6) with fatal visceral gout, compared with 48 controls (18 tissue + 30 serum) from 11 Iranian zoological institutions over 5 year. Renal tissue and antemortem serum were comprehensively analyzed using histopathology, transmission electron microscopy, label-free LC-MS/MS proteomics, and targeted metabolomics with longitudinal sampling (6-7 time points) in five cases - constituting the first temporal metabolomic dataset in reptilian gout research. All cases exhibited diffuse urate deposition on visceral and musculoskeletal surfaces. Histopathologically, extensive tubular necrosis with characteristic radial “starburst” urate crystallization and granulomatous inflammation was consistently observed. Ultrastructurally, transmission electron microscopy confirmed severe, irreversible mitochondrial degeneration in all cases, characterized by organellar swelling, complete cristolysis, and outer membrane rupture. Proteomic profiling identified 347 differentially expressed proteins (fold change ≥ 2 , adjusted $P < 0.05$): purine catabolic enzymes were markedly upregulated (xanthine dehydrogenase 4.9-fold, adenosine deaminase 3.4-fold, guanase 2.9-fold), whereas antioxidant defenses were profoundly suppressed (superoxide dismutase 1 0.29-fold, glutathione peroxidase 1 0.39-fold, catalase 0.31-fold, glutathione peroxidase 4 0.20-fold). Longitudinal metabolomics demonstrated that xanthine accumulation and glutathione depletion (GSH/GSSG decline from 8.2 to 1.2) preceded exponential uric acid elevation by 30-60 d. KEGG enrichment confirmed involvement of purine metabolism ($P = 1.6 \times 10^{-4}$) and reactive oxygen species pathways ($P = 0.006$). Notably, species-specific variability was observed:

C. suchus exhibited the most pronounced purine metabolic upregulation and antioxidant suppression, while *C. yacare* showed relatively mild alterations. Collectively, these findings establish the first quantitative multi-omic reference for reptilian gout and demonstrate that fatal visceral gout is consistently associated with purine metabolic collapse, antioxidant defense failure, and irreversible mitochondrial injury, with species-specific variability suggesting differential genetic susceptibility. These results provide a quantitative framework for early biomarker-based diagnosis and species-specific risk assessment in captive crocodilian populations.

Hilevski, S., Lopes, F.A.C., Metz, G.F., Lemos, R.P.M., Da Anunciação, R.R., Victoria, F. de C. and Siroski, P.A. (2026). Shotgun metagenomic insights into the diversity and potential physiological functions of the gastrointestinal microbiome of the Broad-snouted caiman. Available at [SSRN](#) and [SSRN](#).

Abstract: The gut microbiota is a fundamental component of vertebrate biology, contributing to nutrient acquisition, metabolic regulation, immune function, and host homeostasis. However, its composition and functional potential remain poorly understood in crocodilians. Here, we present the first shotgun metagenomic characterization of the gastrointestinal microbiome of the broad-snouted caiman, *Caiman latirostris*, evaluating microbial composition and predicted metabolic functions across digestive tract compartments under contrasting dietary conditions. Twelve juvenile caimans were assigned to either a carnivorous diet based on chicken byproducts or an omnivorous diet supplemented with heat-treated soybean meal. Samples from the esophagus, stomach, small intestine, and large intestine were analyzed using Oxford Nanopore shotgun metagenomic sequencing, followed by taxonomic and functional annotation with DIAMOND and MEGAN6. Across all samples, the gut microbiota was dominated by the bacterial phyla Bacteroidetes, Firmicutes, Fusobacteria, and Proteobacteria. While Bacteroidetes and Firmicutes remained consistently abundant across treatments, the omnivorous diet was associated with increased relative abundance of Fusobacteria and reduced Proteobacteria. Microbial communities also exhibited marked spatial organization along the gastrointestinal tract, with significant taxonomic turnover and enrichment of Fusobacteria in distal segments ($p < 0.0001$). Functional annotation showed that most predicted genes were involved in carbohydrate and amino acid metabolism and energy production, with the large intestine displaying the greatest diversity of predicted metabolic functions. These findings suggest that dietary composition and gastrointestinal compartment contribute to shaping the taxonomic structure and metabolic potential of the gut microbiome, providing new insights into host-microbiome interactions and digestive physiology in an understudied crocodilian species.

Chen, J.Q. Liu, D., Meng, Q.Y., Yao, Y.T., Lin, C.X., Shi, Y.H., Du, Y., Qu, Y.F. and Ji, X. (2026). Residual yolk depletion matches the establishment of functional oral-intestinal microbiota in hatchling Siamese crocodiles. *iScience* 29: 117047.

Abstract: Newborn reptiles rely on residual yolk as their sole energy source before feeding, yet it is unknown whether functionally competent oral and intestinal microbial communities fully develop before yolk depletion. Using hatchling Siamese crocodiles (*Crocodylus siamensis*), we tested the hypothesis that yolk depletion aligns with the establishment of vital early-life oral and intestinal microbial communities. We profiled oral, intestinal, and environmental microbiomes over 56 post-hatching days with 16S rRNA gene sequencing. Egg-derived microbes acted as the initial colonizing inoculum. Bacterial diversification began soon after hatching. Bacterial colonization in the oral cavity and intestine was non-random and site-specific, with environmental and dietary correlates of microbiota composition being evident at both sites. Critically, pre-feeding oral and intestinal communities possessed phylogenetically diverse bacteria with broad functional capacity.

Our results confirm that yolk depletion coincides with the formation of functionally competent oral and intestinal microbiota in hatchling crocodiles.

Gorza, L.L., Oliveira, E.C., Marcelino, S.A.C., Cordeiro, L.F.M., Nóbrega, Y.C., Borges, E.J.S., Tavares, G.C., Carvalho, M.P.N., Ferrante, B., Nepomuceno, A.C., Vieira, L.T.M., Coutinho, M.E. and Pierezan, F. (2026). Gross, microscopic, and imaging findings of congenital malformations in farmed caimans (*Caiman yacare*). *Veterinary Pathology*.

Abstract: Congenital malformations (CMFs) are structural disorders that arise during embryogenesis, and various forms of these abnormalities have been reported in reptiles. The yacare caiman (*Caiman yacare*) is widely used in commercial farms in the Pantanal region, and studies characterizing CMFs in these animals are scarce. This study describes the pathological and imaging findings of CMFs in farmed caimans. From February 2022 to February 2023, the incubation and maternity of a caiman commercial farm, operating in ranching and farming systems, were monitored. A total of 26 distinct CMFs were identified in 30 farmed caimans. All animals were classified as infantile (9.65 ± 2.69 cm snout-vent length). CMFs were grouped according to anatomical site, with craniofacial disorders (18 cases) being the most frequent findings, followed by spinal malformations (13 cases). Palatoschisis (PC) and cheiloschisis (CL) were reported in 6 yacare caimans, which also exhibited a malformed palatal velum and secondary aspiration pneumonia. Meningoencephalocele was diagnosed in 3 caimans, with brain hemorrhage being a typical secondary lesion in these cases. Anophthalmus, exophthalmos, and cyclopia represented the ocular CMFs. Spinal malformations (kyphosis and scoliosis) were detected in 13 yacare caimans and were thoroughly characterized by the X-ray radiographic analysis. Tail abnormalities were reported in 12 animals, including tail agenesis (1 case) and coiled tail (11 cases). Other sites of CMFs include the limbs, the coelomic wall, and the skin. Radiographic assessments were obtained from all 30 CMFs, providing detailed information on these lesions.

Zendejas-Huerta, E.N., Ahuja-Aguirre, C., López-deBuen, L., Viveros Peredo, S. and Domínguez-Mancera, B. (2026). Growth, skin quality and stress of farmed Morelet's crocodiles (*Crocodylus moreletii*) housed communally or individually during the finishing stage. *Multidisciplinary Science Journal* 9: e2027061.

Abstract: This study evaluated the effect of housing type (communal versus individual enclosures) during the finishing stage on growth, skin quality, and chronic stress of farmed Morelet's crocodiles (*Crocodylus moreletii*). A total of 292 subadult crocodiles were included: 164 housed individually and 128 communally. Growth variables (total length, belly width, and live weight), skin quality, and corticosterone concentrations were assessed at the beginning and end of the finishing stage. The market price for the skin was determined at the end of the finishing stage. Crocodiles housed in communal enclosures showed greater total length, live weight, and growth gain ($P < 0.05$). In contrast, crocodiles housed individually exhibited greater skin quality with greater commercial value ($P < 0.05$), as well as lower corticosterone concentrations, at the end of the finishing stage ($P < 0.01$). Correlation between percentages of TL gain and LW gain was higher in CE ($r = 0.74$) than in IE ($r = 0.31$). The coefficient of determination was greater in CE ($R^2 = 0.54$) than in IE ($R^2 = 0.09$). However, variance was greater in CE (TL = 0.08; LW = 3.2) than in IE (TL = 0.04; LW = 2.4). These results suggest a trade-off between growth and skin quality, as well as a different stress response depending on housing type. While communal housing promoted greater growth, individual housing favored more homogeneous growth and skin quality, and reduced the chronic stress response. However, interpretations regarding animal welfare should be made cautiously, as corticosterone was used as one indicator of chronic stress and does not reflect overall welfare status.

Zatta Fieker, C., Alves Rondon, I.A., Gonçalves dos Reis, M., Tissiani, A.S., Marques, M.I. and Schuchmann, K-L. (2026). Using unmanned aerial vehicles to estimate the abundance, density, body size structure, and seasonal site use of *Caiman yacare* in the northeastern Pantanal, Brazil. [Studies on Neotropical Fauna and Environment](#).

Abstract: Wildlife research in natural habitats is essential for understanding natural history; however, substantial financial and sampling efforts are required. Cost-effective methodologies, such as drone applications, can overcome these limitations. Although this approach has already yielded substantial results, applications in studies on crocodilians remain scarce in South America. Given this, the objective of this study was to assess the use of drones in population surveys of *Caiman yacare* (Daudin, 1802) in bays of Parque SESC Baía das Pedras, northeastern Pantanal. Seasonal sampling was conducted by flying over 7 bays, taking photos, and counting individuals in real time. Water temperature and depth were measured to examine their associations with site use. A total of 1118 detections were recorded, with the highest counts occurring during the dry season. Total length was estimated for 249 individuals from aerial images, and smaller size classes were the most common. Seasonality strongly influenced the number of caimans detected. Counts were highly heterogeneous among bays. Water temperature was not associated with counts, whereas water depth showed a weak positive association. In addition to providing valuable information on the caiman population in the study area, these results support the use of drones for crocodilian population surveys.

Ogorode, I.O., Ito, E.E., Oriakpono, O.E., Vincent-Akpu, I.F., Babatunde, B.B. and Sikoki, F.D. (2026). Relative abundance of *Osteolaemus tetraspis* in Uwa, Edumanom and Ogbe-Ijaw bushmeat markets in the Niger Delta region, Nigeria. *BMC Zoology* 11: 25.

Abstract: The dwarf crocodile *Osteolaemus tetraspis* is globally listed as Vulnerable, yet remains heavily harvested across West and Central Africa particularly in the Niger Delta, Nigeria. This study assessed the spatio-temporal variation in the relative abundance of *O. tetraspis* across three major bushmeat markets: Uwa (Edo State), Edumanon (Bayelsa State), and Ogbe-Ijaw (Delta State) to inform conservation and management interventions. Bushmeat market surveys were conducted fortnightly between October 2021 and April 2022. All crocodiles encountered were counted and measured across three size classes (60, 90, and ≥ 120 cm). A negative-binomial generalized linear mixed model (GLMM) was fitted to monthly counts of *O. tetraspis* to account for overdispersion in the abundance data. Temporal (Month) and spatial (Market location) effects, as well as their interaction, were treated as fixed effects. A total of 158 *O. tetraspis* individuals were recorded, dominated by medium-sized (39.24%) and large-sized (39.24%) individuals. Uwa accounted for the highest proportion of individuals (60.76%), followed by Edumanon (25.32%) and Ogbe-Ijaw (13.92%). The negative-binomial GLMM model indicated significant effects of Month ($\chi^2_6 = 19.82$, $p < 0.01$) and Market Location ($\chi^2_2 = 10.46$, $p = 0.005$), as well as a significant Month $\times$ Market interaction ($\chi^2_{12} = 23.17$, $p = 0.018$), demonstrating that temporal patterns in abundance differed among markets. The marginal R^2 value ($R^2_m = 0.48$) indicated that fixed effects accounted for a substantial variation in monthly abundance. Temporal declines were pronounced in April across all markets. Trade pressure on *O. tetraspis* is greatest during the dry-season months of October-February, with Uwa and Edumanon emerged as the principal markets contributing to the observed trade. The dominance of medium- and large-bodied crocodiles in the trade raises concerns about depletion of reproductive adults and long-term population collapse. These findings highlight the need for market-specific regulatory strategies, dry-season harvest restrictions, enhanced monitoring in high-pressure markets, and livelihood support programs. Integrating these actions with community-based conservation are critical for sustaining remaining *O. tetraspis* populations in the Niger Delta.

Truter, M., Hüsken, A., Schwelm, J., Sures, B., Malherbe, W. and Smit, N.J. (2026). Completing the first molecular and morphological characterised life cycle of a crocodilian-infecting diplostomid, *Neofibricola smiti* (Digenea: Diplostomidae). [Parasitology](#).

Abstract: The life cycles of trematodes infecting crocodilians remain poorly understood, with most species known exclusively from adult stages recovered from definitive hosts. The present study elucidates the life cycle of *Neofibricola smiti* Achatz, Martens, Kudlai, Junker, Boe et Tkach, 2022 from South Africa and identifies *Bulinus* sp. as first intermediate host, representing the first confirmed first intermediate host association for a crocodilian-infecting diplostomid. In addition, a metacercaria recovered from the eye viscera of *Clarias gariepinus* (Burchell, 1822) expands the known range of second intermediate hosts for *N. smiti* to include a clariid fish. Phylogenetic analyses of partial 28S rDNA, ITS2 rDNA, and COI mtDNA sequences generated from sporocysts, cercariae, and a metacercaria confirmed conspecificity with the sexual adult specimens previously described from the Nile crocodile, *Crocodylus niloticus* Laurenti, 1768, and metacercariae identified from Müller's clawed frog, *Xenopus muelleri* (Peters, 1844). The occurrence of metacercariae in both amphibian and fish hosts suggests either a broader second intermediate host range or more complex transmission pathways including paratenic host use, as has been demonstrated in other diplostomids. This study thus presents the first fully elucidated and molecularly characterised life cycle for a crocodilian-infecting diplostomid and advances our current understanding of host associations and transmission pathways within the Diplostomidae.

Flint, J., Lewis, Z.J., Vik, D., Flint, M. and Hale, V. (2026). Gut microbial differences in healthy and sick farmed American alligators (*Alligator mississippiensis*) during a disease outbreak. [Veterinary Microbiology](#) 321: 111185.

Abstract: American alligators (*Alligator mississippiensis*) in production systems within the United States experience occasional disease outbreaks and die-offs. However, outbreak management is limited by an incomplete understanding of common causes of mortality in commercially raised crocodilians. In this study, we examined the gut microbiota of healthy ($n = 18$) and sick alligators ($n = 17$) during an active outbreak on an alligator farm in Southeast, USA. Sick alligators were all exhibiting generalized signs of disease. The gut microbial composition of alligators with disease differed significantly from that of healthy alligators. One ASV in the genus *Peptostreptococcus* and one in the genus *Wolinella* were found at increased relative abundances in alligators with disease while one ASV, *Clostridium sensu stricto* 13, was found at increased relative abundances in healthy alligators. Notably, the *Peptostreptococcus* ASV was found in all but two of the 17 alligators with disease and was not detected in any healthy alligator. *Chlamydia* species were also found at increased abundance in alligators with disease; although, *Chlamydia* was widely present in healthy alligators too. Additional studies are required to assess the clinical significance of these taxa as primary / secondary pathogens or protective (probiotic) species.

Winans, M.M. (2026). Exploring Behavioral and Physiological Indicators of Welfare for American Alligators (*Alligator mississippiensis*). PhD thesis, Ohio State University, Columbus, Ohio, USA.

Abstract: The ability to accurately assess the welfare of reptiles across managed care systems is essential, particularly given the scientific consensus that these animals have the capacity for an array of both positive and negative experiences. The capacity for evidence-based assessments is especially important for American alligators (*Alligator mississippiensis*), which are a unique example of a megafauna species endemic to the United States, commonly found within zoo and aquarium facilities, and serving as the focal species of a key commercial production system. Through this

body of work, we explored behavioral and physiological indicators of welfare in this species across managed systems. First, we documented the behavioral repertoire of zoo-housed alligators, observing a species-appropriate, diverse repertoire, uneven use of habitat space, and moderate levels of social proximity. Within the commercial farm setting, we evaluated alligators' health status after being housed in communal and individual housing systems and found evidence of potential health challenges after extended durations in both pen types. We characterized a suite of blood-based biomarkers across wild, zoo, and farm-housed alligators, using reference intervals as a point of comparison. Given the limitations of this approach, we then explored a novel application of allostatic load assessment in American alligators, including describing an example of practical application of allostatic load assessment for a farm setting. Collectively, this work provides a preliminary foundation to support increased efforts to prioritize the welfare of this species across its native range, zoological facilities, and the commercial farming industry.

Rachuene, P., Nemutandani, K.R., Mugwabana, J.T. and Tyasi, T.L. (2026). Impact of poxvirus infection on crocodile skin quality: A systematic review. *American Journal of Animal and Veterinary Sciences* 21(2): 019.

Abstract: Crocodile poxvirus infection causes small superficial lesions covered by dark brownish crusts or scabs. This infection is of importance in crocodile farming due to its potential impact on the tanned hide. The objective of this study was to systematically review literature on the effect of poxvirus infection on crocodile skin quality. The study systematically used four search engines: Google Scholar, PubMed, ScienceDirect, and Web of Science to search for literature. A total of five articles (n= 5) were included in the study. The results showed that only three (n= 3) articles reported that poxvirus infection has an effect on raw/tanned skin quality in crocodiles, depending on harvest time, as well as stage and severity of the infection. The limitation of this systematic review is that out of the five included articles, only three ascertained the impact of crocodile poxvirus on the raw/tanned skin. The systematic review concluded that poxvirus infection has an effect on the quality of crocodile hides.

Shaffer, A.B. (2026). A New Crocodylian from the Eocene (Ypresian) of Wyoming (Greater Green River Basin, USA) and the Origins of Longirostres. MSc thesis, University of Iowa, Iowa City, IA, USA.

Abstract: A new species of crocodylian is herein described based on fossils originating from the lowermost Bridger Formation (Bridger A subunit) of southwestern Wyoming. This new taxon adds to the already speciose eusuchian fauna of western North America during the early Eocene and underscores the potential for cryptic diversity among fossils from this region and interval. While exhibiting general morphology similar to other North American Longirostres-line crocodylians (eg "*Crocodylus*" *affinis*, *Brachyuranochamps*, *Prodiplocynodon*), a number of morphological characters distinguish the new species from these other taxa, including the presence of prominent anteroposteriorly oriented preorbital ridges, posterodorsal premaxillary processes that extend to between the third and fourth maxillary alveoli, the presence of a posterior maxillary process within the lacrimal, and the ectopterygoid maxillary rami being separated from the suborbital fenestrae by the maxillae. Phylogenetic analysis of a new morphological dataset recovers the new Bridger Formation taxon in a derived position relative to other North American Longirostres-line crocodylians and near the divergence of crown-Longirostres. These phylogenetic results also have important implications for early crocodylian evolution and highlight the importance of North American Cretaceous-Paleogene fossils in understanding the origins of Longirostres.

Davies, S., Tasca, A., Alvarez-Carretero, S., Brochu, C., Pisani, D.

and Donoghue, P.C.J. (2026). Competing methods of divergence time estimation recover diverse evolutionary timescales. *Proceedings of the Royal Society B: Biological Sciences*.

Abstract: Molecular clocks convert evolutionary distances into geological times to infer time-scaled phylogenies. Methods differ in terms of fossil calibration strategy (node versus tip) and whether they use molecular and/or morphological data, but their relative performance remains unclear. Given their well-preserved fossil record, we use Crocodylia to interrogate common approaches to timescale estimation using a combination of calibration strategies and datatypes in MrBayes. We found calibration strategies had a much greater impact than datatype, with node-calibrated timescales producing younger ages than tip calibration. The older ages recovered by tip-calibrated approaches imply an Early Cretaceous origin (ca. 125-102 Ma) of Crocodylia inconsistent with the stratigraphic record, while node calibration produces more credible estimates, including a Late Cretaceous origin (ca. 95-78 Ma). Performing tip calibration with a fossilised birth-death process produced an intermediate timescale, estimating an Early-Late Cretaceous origin (ca. 118-95 Ma). These timescales support materially distinct scenarios for crocodylian evolution. We show these disparities among calibration strategies are driven by differences in the structure of their underlying priors, with tip-calibrated timescales biased towards unrealistically ancient ages. Our results highlight the need for future analyses to explore hybrid calibration strategies that treat node and tip dating as compatible, rather than competing, approaches.

Seymour, R.S. (2026). Crocodiles can't fly. Birds can. Scientists have finally figured out why. *The Conversation. Informit.* T2026081400000790869831349.

Abstract: New research suggests crocodiles used to have hot blood and fast metabolisms, but gave it all up to lurk underwater waiting for prey.

Ivory II, A.A., Brock, K.M., Martin, L., Goodhard, A., Donovan, V.M. and Johnson, S.A. (2026). Alligators, Raccoons, and Bats Underfoot: Wildlife Living in Stormwater Sewers: WEC485/UW554, 8/2026. *Electronic Data Information Source* 2026(4): Jul-Aug.

Abstract: This publication explains how wildlife use the urban ecosystem and sewers. Cities reduce natural spaces for wildlife, but animals adapt by using human-made structures in surprising ways. Sewers designed to move stormwater provide hidden habitats and travel corridors for a variety of wildlife. In Alachua County, camera traps documented 35 species, including raccoons, opossums, bats, birds, reptiles, and invertebrates, using sewers for shelter, foraging, and safe movement under roads. Some species, like raccoons and bats, roosted or dened inside the pipes. Sewer design, pipe size, water flow, and surrounding development influenced which animals were present. While sewers benefit urban wildlife, they also pose risks: animals become trapped during floods or maintenance. Knowing that animals use the stormwater systems, homeowners and city managers can act to protect both animals and protect both animals and people by, for instance, installing ramps or screens to reduce entrapments.

Wilson, O.E., Moreno-Bernal, J.W., Suarez, C., Cardozo Tovar, F., Vanegas, A., Vanegas, R., Shirley, E.A., Holroyd, P.A. and John-Paul Zonneveld, J-P. (2026). Physical evidence of crocodylian predation on ungulates in the Middle Miocene of Colombia. *Journal of Vertebrate Paleontology*.

Abstract: South American fossil mammalian assemblages contain a relatively low ratio of predators to prey. Consequently, large non-mammalian predators occupy a major ecological role. In the Middle Miocene assemblage of La Venta, Colombia, crocodyliforms have

been previously proposed as the most significant predators of large mammals. Here we present ichnological evidence for predation by giant crocodylians of three large ungulates from La Venta: *Pericotoxodon platignathus*, *Xenastropotherium kraglievichi*, and *Granastropotherium snorki*. A partial cranium of *P. platignathus* preserves a large, bisected circular puncture mark. Part of a distal femur of *P. platignathus* includes a series of semicircular puncture marks and smaller pits. Two astragali mandibles contain multiple puncture marks associated with significant deformation. In all cases, the most likely predator is interpreted as *Purussaurus*, based on the size and shape of the puncture marks and the presence of significant deformation to the cortical bone. The recognition of the ichnotaxon *Knethichnus parallelus* in a *Xenastropotherium* mandible probably relates to a separate scavenging event by a ziphodont crocodyliform, likely *Langstonia huilensis*. The similarities between the trace fossils associated with *Purussaurus* predation and bite marks produced by modern crocodiles support the use of modern crocodiles as analogues to interpret the ecology of Miocene giant crocodylians.

Mohammadzadeh, P. and Ziaee, F. (2026). Idiopathic penile prolapse in a juvenile Nile crocodile (*Crocodylus niloticus*): A multimodal diagnostic investigation. *Veterinary Record Case Reports* 14(3): e70539.

Abstract: Idiopathic penile prolapse was diagnosed in a juvenile male Nile crocodile (*Crocodylus niloticus*) maintained under captive conditions. A systematic, multimodal diagnostic approach was undertaken, incorporating physical examination, haematology, serum biochemistry, advanced imaging (contrast-enhanced computed tomography angiography and ultrasonography), targeted histopathology and microbiology. Findings were most consistent with acute, localised ischaemic injury to the prolapsed phallus accompanied by a mild, self-limiting systemic stress response. No evidence of trauma, infectious cloacitis, congenital anatomical abnormality, gastrointestinal or urogenital obstruction, or nutritional/metabolic disease was identified. Low-level environmental contaminants detected in environmental samples represented background exposure and were not causally associated with the prolapse. Surgical management comprising conservative debridement and anatomical reduction resulted in rapid, uncomplicated recovery with no recurrence during a 3-month follow-up. This case emphasises the diagnostic complexity of penile prolapse in reptiles and provides a systematic investigative framework to support exclusion of common primary aetiologies.

Abidin, N.F.Z., Zawawi, M.N.A., Aziz, T.J.I.A. and Fahmi, A.H.M. (2025). Legenda Bujang Senang: From folklore to future, revitalizing Malaysia heritage through game based learning. *International Journal of Business and Technology Management* 7(11): 491-498.

Abstract: This study explores the integration of Malaysian folklore into game-based learning through the development of a 2D platform game titled Legenda Bujang Senang. Rooted in Sarawak's cultural heritage, the game reimagines the legendary tale of Bujang Senang, a mythical crocodile, within an interactive digital environment. Designed with four levels, the game incorporates ten culturally significant objects, each accompanied by educational descriptions to enhance players' understanding of Sarawak's traditions. Sixty-seven respondents of varying gender, age, and gaming experience completed a questionnaire to assess the potential of game-based learning in promoting Malaysian folklore and heritage. Additionally, twelve participants aged 12 to 17 engaged in gameplay testing to evaluate the game's effectiveness in terms of engagement, cultural learning, and usability. Findings suggest that game-based learning can effectively foster interest in local heritage among younger audiences, offering a dynamic medium for cultural preservation and education.

Lemaire, J., Mangione, R., Fusani, L. and Canoine, V. (2026).

Embryonic exposure to mercury contamination is associated with elevated corticosterone and lower body condition in wild Smooth-fronted caiman hatchlings. [Environmental Research](#).

Abstract: Mercury (Hg) is a worldwide contaminant that affects all ecosystems, yet most evidence of its biological impacts comes from fish, birds, and mammals, leaving reptiles comparatively understudied. Crocodylians may be particularly vulnerable to Hg due to their long lifespans, high trophic positions, and occurrence in tropical and subtropical regions affected by artisanal and small-scale gold mining. We investigated the effect of Hg contamination during embryonic development in the Smooth-fronted caiman (*Paleosuchus trigonatus*, n= 15), using claws, scutes and red blood cells (RBC) as a non-invasive proxy for *in-ovo* exposure. We found a positive relationship between plasma corticosterone (CORT) concentration and claw ($R^2 = 0.65$, $p < 0.001$), scute ($R^2 = 0.67$, $p < 0.001$) and RBCs ($R^2 = 0.39$, $p = 0.018$) Hg concentrations, suggesting that even low embryonic Hg exposures may alter the endocrine status of hatchlings. We further assessed body condition in relation to CORT concentration to explore potential phenotypic effects and found a negative relationship ($R^2 = 0.48$, $p = 0.004$). Our findings support the use of keratinized tissues as a minimally invasive biomonitoring matrix for assessing *in-ovo* Hg exposure in crocodylians and also highlight the need to integrate contaminant dynamics into conservation strategies for species inhabiting Hg-impacted ecosystems.

Van Dooren, T. (2026). *The Craft of Poisoning: Learning to Live in Toxic Worlds* Cambridge University Press: UK.

Summary: Since their introduction in 1935, cane toads have spread out across the top of Australia, leaving a wave of death in their wake: animals poisoned by the unfamiliar toxins they carry. While management efforts have focused on lethal interventions, one group of scientists has been attempting to teach native animals - including monitor lizards, quolls, crocodiles, and others - not to eat toads through a 'conditioned taste aversion' that is produced with the use of nauseating toxins. This Element explores the history, ethics, and emergent possibilities of this ongoing multispecies pedagogical experiment. It asks how the toxic substances that are deployed by both toads and scientists open up new opportunities for learning, for becoming differently together, for reshaping ecosystems and shared lives, while also carrying with them significant, often mortal, dangers. Ultimately, the text explores a complex space of biodiversity conservation centred on the cultivation of a thoroughly imperfect, but hopeful, 'craft of poisoning'.

Leiva, P.M.L., Frutos, A.E., Piña, C.I., Simoncini, M.S. and Labaque, M.C. (2026). When it rains, eggs gain: Maternal investment in eggs and progeny in caiman. [Journal of Zoology](#).

Abstract: Environmental factors influence females and the resources they accumulate and invest in their eggs. We studied the influence of climatic variables and corporal attributes of *Caiman latirostris* females on egg characteristics, hatching success and hatchling size. We recorded reproductive metrics of female body and physiological condition, and collected their entire clutches. One group of the eggs in a clutch was assigned for fatty acid profile analysis (FA), while another was used for artificial incubation. We also registered the precipitation and temperature of previous reproductive season and prior to oviposition. Eggs from females with better body condition had a higher proportion of the essential fatty acid (EFA) C20:4 and higher polyunsaturated FA content. EFAs such as C20:4, C22:5, and C22:6 in eggs were positively associated with seasonal precipitation and temperature, suggesting that rainy years are beneficial for maternal investment. In contrast, C18:2 in eggs was negatively associated with precipitation during vitellogenesis but positively correlated with maternal tissue fatty acids. The high proportion of C18:2 may reflect a greater consumption of prey rich in C18:2, such as insects or mollusks, possibly associated with a less

diverse diet resulting from changes in resource availability driven by climatic conditions during these periods. High C18:2 content in eggs was associated with lower hatching success. Therefore, years with abundant precipitation during vitellogenesis are advantageous because they may increase prey diversity and resource availability for females, allowing greater transfer of physiologically important fatty acids to eggs.

Leyshon, C.L., Cottle, A.L., Cutter, S.M., Shilton, C.M. and Isberg, S.R. (2026). Palliative care of a large captive saltwater crocodile (*Crocodylus porosus*) with metastatic digital squamous cell carcinoma. [Australian Veterinary Journal](#).

Abstract: A 4.90 m male saltwater crocodile, “Burt”, was first noticed with irregular keratinisation involving the claw of the first digit of his left hind limb in December 2021. Three months later (March 2022), the digit had significantly increased in size and was noticeably affecting his weight-bearing ability. An excisional biopsy was performed, involving digit amputation. Histopathology revealed that the lesion was a squamous cell carcinoma (SCC), complicated by ulceration and opportunistic *Morganella morganii* infection. Within 3 months, the mass recurred. In June 2022, a second amputation was performed, this time through the distal femur. Histology revealed that although clusters of neoplastic cells were present within lymphatics near the main mass, the amputated margins were clear of SCC. After both interventions, the crocodile resumed eating and behaving normally within 24 h, although after the second surgery he was observed to have some balancing issues as he readjusted to the missing limb. In June 2024, the crocodile’s food consumption declined; he lost interest in interacting with the keepers, displayed strong food preferences that changed frequently and generally became less responsive and active. Despite no local reoccurrence of the mass 2.5 years post-surgery, the crocodile succumbed to metastasis in the heart and liver, causing cardiac failure and terminal drowning. This study provides insights into the progression of digital SCC and a discussion of the palliative care options that are available for large crocodilians.

Buenfil-Rojas, A.M., Iida, M., González-Jáuregui, M., Alvarez-Legorreta, T., Barão-Nóbrega, J.A.L., Kanerva, M., Ochiai, M. and Iwata, H. (2026). Non-lethal scute transcriptomics reveals biomarker candidates for environmental stress in Mexican Morelet’s crocodiles. [Comparative Biochemistry and Physiology C; Toxicology and Pharmacology](#).

Abstract: Aquatic ecosystems in southeastern Mexico face increasing chemical pollution, yet non-lethal molecular tools to monitor native reptile populations remain limited. We profiled RNA-seq from non-lethal caudal scute biopsies of 43 Morelet’s crocodiles (*Crocodylus moreletii*) across six wild populations and a captive reference group. After mapping to the *Alligator mississippiensis* genome, 18,107 expressed genes were analyzed using PCA, DESeq2, WGCNA, and single-sample pathway scoring. Wild crocodiles showed a consistent shift along a dominant transcriptional axis contrasting dermal/ECM remodeling with epidermal-metabolic/barrier programs. A conserved core of DEGs and wild-associated modules were enriched for extracellular matrix organization, ER/secretory stress handling, vesicle trafficking and adhesion pathways, while union DEGs captured site-specific alterations in lipid metabolism, ion transport, neuronal signaling and developmental processes. Integrating network connectivity, differential expression strength, statistical support, and ROC performance, we prioritized 10 up-regulated genes as a preliminary scute biomarker panel that discriminates wild from captive individuals. This landscape-scale scute transcriptomic framework supports non-lethal omics-based biomonitoring in crocodilians and other non-model wildlife. Haldar, A. and Ray, S. (2026). New biological insights from osteoderm histology of *Venkatasuchus armatum* (Pseudosuchia: Aetosauria). [The Anatomical Record](#).

Abstract: In this contribution, we studied the histology of several selected paramedian and lateral osteoderm(s) of the Late Triassic aetosaur *Venkatasuchus armatum*, known from the lower part of the Dharmaram Formation of Pranhita-Godavari Basin in India to assess the growth strategy and functional attributes. The sections revealed a typical diploe structure comprising compact outer and basal cortices surrounding a large and cancellous inner core. The osteoderms had an overall slow and punctuated growth strategy based on the predominance of avascular lamellar bone, crossed parallel-fibered bone, and multiple LAGs. Extensive secondary remodeling, in the form of secondary osteons of several generations, is seen in the ornamented outer cortex, especially in the ridges or peaks that contrasted with its absence and uniform histological features in the unornamented and consistently thick basal cortex. Other features included high abundance of dense bundles of Sharpey’s fibers or extrinsic fibers that suggested presence of an external covering, possibly a keratinized sheath on the osteoderms. Comparison with other aetosaurs showed that the Indian taxon underwent pronounced bone remodeling, which may be explained by influence of regional or developmental factors and/or related to reproductive activity in an ovulating female. Although crossed parallel-fibered bone tissue differentiates aetosaurian osteoderms from other pseudosuchian osteoderms, there are distinct differences in osteodermal histology and growth strategies among various aetosaurian taxa.

Wang, Z., Wang, Y., Hong, H., Luo, Y., Chen, B., Dia, V.P., Wu, K. and Fan, H. (2026). Isolation, gastrointestinal stability, intestinal transport, and allergenicity of antioxidant peptides derived from crocodile (*Crocodylus siamensis*) blood proteins. [Food Chemistry](#).

Abstract: Antioxidant peptides derived from crocodile blood remain poorly characterized, regarding defined sequences, gastrointestinal stability, intestinal transport, and allergenicity. In this study, antioxidant peptides were generated from crocodile (*Crocodylus siamensis*) blood proteins via enzymatic hydrolysis. Two peptides (MLHVGPEIAPL and AAHYPKDFGL), prepared by pepsin, exhibited strong antioxidant activity, with 1, 1-diphenyl-2-picrylhydrazyl (DPPH) radical-scavenging activity of 10.39-14.09 μmol Trolox equivalents (TE)/mg and reducing power of 2.43-5.00 μmol TE/mg. Simulated gastrointestinal digestion revealed that AAHYPKDFGL was further hydrolyzed into shorter peptides (AAHYPK and DFGL) with retained activity. These peptides could pass the Caco-2 monolayer with apparent permeability coefficients of $2.80\text{--}11.98 \times 10^{-7}$ cm/s, despite being degraded by aminopeptidase N to varying degrees. They reduced cellular oxidative stress (decreased superoxide/malondialdehyde levels) without affecting major antioxidant enzymes. No significant allergenicity was detected for these peptides. These findings highlighted crocodile blood proteins as an underexplored source of antioxidant peptides for functional food application.

Wang, X., Shi, P., Yao, W., Wang, J. and Niklas, K.J. (2026). The surface area vs. volume scaling relationship of reptilian eggs follows a 2/3-power law. *Journal of Herpetology* 60(3).

Abstract: The surface area (S) vs. volume (V) scaling relationship of avian eggs follows a 2/3-power law, reflecting geometric principles akin to classical Euclidean shapes. However, it is unclear whether this holds for reptilian eggs. We tested the 2/3-power law in reptilian eggs using 120 eggs each from the turtles *Mauremys reevesii* and *Pelodiscus sinensis*. The explicit Preston equation (EPE), a model used for describing avian egg geometries, was fitted to digitized 2D profiles to estimate the S and V of the reptilian eggs assuming that the profiles adhered to the solid-of-revolution hypothesis. Empirical V was measured by water displacement. The EPE described all profiles accurately. There was no significant difference between the predicted and observed volumes given that the 95% confidence intervals for the intercept and slope of ln-ln regression curves included 0 and 1, respectively. Across the data set, S scaled with respect to V according to a 2/3-power law: the 95% confidence

intervals for the slopes of $\ln(S)$ vs. $\ln(V)$ included $2/3$. Therefore, the geometric principles of avian egg geometries also apply to reptiles, revealing a conserved relationship between the surface-area-to-volume proportionality coefficient ($k = S/V^{2/3}$) and egg shape as quantified by the aspect ratio $p = b/a$ (where a is half the egg length and b is the semi-minor axis of the underlying ellipse estimated by the EPE), which spans both avian and reptilian eggs. The data appear to reflect a universal geometric constraint on amniote egg shape, which requires additional analyses to confirm its reality.

Ningsih, Y.R., Manurung, S.P., Permana, S., Aditya, N.O., Puspo, T.R., Syahrani, H. and Sari, Y.A. (2026). Something to see, do, and buy: Integrating safety, animal welfare, and visitor experience in conservation tourism at Buaya Asam Kumbang. *Sustainability: Theory, Practice and Policy* 6(1): 52-65.

Abstract: The sustainability of conservation tourism depends equally on wildlife preservation and the quality of the visitor experience. However, the integration of visitor safety, animal welfare, and interactive learning remains underexplored in destination management. This study investigates visitors' perceptions of facilities, safety, and educational value at the Buaya Asam Kumbang Sanctuary, Medan, and analyzes their impact on the overall tourism experience. Employing a qualitative descriptive design, data were collected from September 2024 to January 2025 through semi-structured interviews, field observations, and documentation involving 30 informants. Data saturation and methodological triangulation were applied for analysis. Findings reveal that visitor perceptions align with the "something to see, do, and buy" framework but extend it significantly. Physical infrastructure and safety primarily shape initial impressions. Interactive activities, such as crocodile feeding, offer high educational value, yet this is strictly contingent upon visible staff supervision. Notably, visitors evaluate safety and animal welfare not as separate domains, but as a singular, integrated indicator of management quality. Furthermore, the lack of age-differentiated ticket pricing and limited food outlets were identified as critical unmet needs. Theoretically, this study expands the conventional attraction framework by embedding ethical and risk dimensions. Practically, it recommends implementing age-based ticketing, expanding culinary services, and formalizing transparent supervision protocols to enhance visitor satisfaction and destination sustainability.

Healy, C. and Neale, T. (2026). Crocodiles, colonialism, and Australian television. Chapter 9 in *The Anthropocene and Visual Culture in Australia*, ed. by L. Williams and H.McDonald. Routledge: UK.

Silva, K.R.P., Milaneze, A.M.I., Pinheiro Lima, A.C., Correa, A.C.L., Vilharba, B.L. de A. and Balestiri, M.F. (2026). Avaliação etológica e dinâmica tempoal do comportamento social de juvenis de *Caiman yacare* em ambiente controlado. 49º Congresso da Associação de Zoológicos e Aquários do Brasil 9.

Resumo: O estudo investigou o comportamento social do jacaré-do-pantanal (*Caiman yacare*) no Bioparque Pantanal, por meio de análises observacionais de três padrões: batida, amontoar e nado, ao longo de três meses. Foram avaliados 10 indivíduos juvenis com auxílio de vídeos e softwares específicos. Observou-se predominância de eventos pontuais, com maior frequência de batida, seguida de amontoar e nadar. O nado variou entre 5.1 s e 12.9 s (média de 8.52 s). Os resultados indicam variabilidade moderada e reforçam a importância de estudos mais aprofundados para compreensão comportamental, manejo, bem-estar e conservação *ex situ*.

Viana, A.L.G., Oliveira, S.E.A., Siqueira, L. and Sousa, E.L. (2026). Protocolo de contenção de Jacaré-Tinga (*Caiman crocodilus*

crocodilus) para realização de exame de imagem. 49º Congresso da Associação de Zoológicos e Aquários do Brasil 9.

Resumo: Este trabalho relata a contenção química de um jacaré-tinga (*Caiman crocodilus crocodilus*) macho para exame radiográfico. Para a realização do exame de imagem, fez-se a contenção química com dexmedetomidina (0.03 mg/kg), cetamina (15 mg/kg) e midazolam (0.5 mg/kg, IM). O exame revelou opacificação pulmonar sugestiva de pneumonia e presença de corpos estranhos minerais nos segmentos intestinais. A associação dos anestésicos mostrou-se eficaz, minimizando o estresse metabólico e criando segurança para o animal e para o profissional. Exames radiográficos permitem a identificação de patologias internas essenciais para a clínica de répteis.

Wang, M., Li, C., Tian, Y., Liu, Z., Ye, S., Yu, J., Guo, G., Fan, L., Yang, N., Zeng, J., Zheng, J. and Li, X. (2026). Multidrug-resistant *Providencia rettgeri*: An emerging pathogen in farmed Siamese crocodiles (*Crocodylus siamensis*) in Hainan, China. *Transboundary and Emerging Diseases* 2026(1): e5761973.

Abstract: The Siamese crocodile (*Crocodylus siamensis*) farming industry in China, particularly in Hainan Province, has grown substantially, yet it faces increasing threats from infectious diseases. *Providencia* spp., especially *P. rettgeri*, are increasingly reported in reptilian disease outbreaks, but their epidemiological and pathogenic profiles in farmed *C. siamensis* remain poorly understood. In this study, necropsy and histopathological examination of 18 deceased juvenile Siamese crocodiles from three farms in Hainan Province, China, revealed severe multiorgan lesions indicative of septicemia. Sixty-five *Providencia* isolates were recovered and assigned to four species-level clusters (*P. rettgeri*, *P. stuartii*, *P. hangzhouensis*, and *P. alcalifaciens*) via 16S rDNA and fusA phylogenetic analyses. Most isolates exhibited strong motility but weak biofilm-forming ability. Crucially, all 65 isolates were multidrug-resistant and carried diverse antimicrobial resistance genes (ARGs), with 74% harboring class 1 integrons. Virulence-associated genes (VGs) were widespread. Zebrafish challenge assays confirmed that all five representative isolates were pathogenic, with *P. rettgeri* strains PL-425 and PL-688 exhibiting the highest virulence (100% mortality within 24-30 h). Whole-genome sequencing of PL-425 identified multiple virulence loci related to motility, capsule, adhesion, and toxins. These findings identify multidrug-resistant *P. rettgeri* as a dominant and highly virulent pathogen in farmed Siamese crocodiles, highlighting its emergence as a significant threat to the industry and underscoring the urgent need for integrated surveillance and antimicrobial stewardship.

Trujillo V., S.K., Gomez Olivares, J.L., Ramírez Romero, P., López Luna, M.A., Milic, M., Sánchez Alarcón, J., Valencia Quintana, R. and Montes, S. (2026). Soil Pb and Cd accumulation and age-dependent biochemical responses in *Crocodylus moreletii*: Evidence of chronic contamination in a protected urban lagoon. [Research Square](#).

Abstract: Laguna de las Ilusiones (LI) is an urbanized, hydrologically restricted lagoon in Tabasco, Mexico, subject to sustained anthropogenic pressure. This study evaluates lead (Pb) and cadmium (Cd) concentrations in soil and water and their association with biochemical biomarkers in a wild population of *C. moreletii*. Environmental samples were analyzed by atomic absorption spectrophotometry, and blood samples were collected to assess cholinesterases (AChE, BuChE) and hepatic enzymes (AST, ALT, GGT), using a captive population as reference. Soil Pb and Cd concentrations were significantly higher than in water and correlated with organic matter and pH. Wild crocodiles showed significantly elevated AChE, BuChE, AST, and ALT activities relative to the reference group ($p < 0.05$), independent of sex but varying across age classes, suggesting ontogenic modulation of physiological responses. Although direct causal relationships cannot be established, the co-

occurrence of soil metal enrichment and altered enzymatic profiles indicates chronic environmental stress, underscoring the value of sentinel species biomarkers for long-term contaminant monitoring in tropical urban wetlands.

Basten, A., Van der Bij, P., Berings, W., Boerman, S.A.C.M. and Vellekoop, J. (2026). A study of the early Oligocene and early Miocene *Diplocynodon* (Crocodylia) material housed in the Filhol collection of KU Leuven (Belgium). *Geologica Belgica* 29(1-2).

Abstract: *Diplocynodon* is an enigmatic extinct genus that is generally considered to be part of the Alligatoroidea, Crocodylia. While Alligatoroidea potentially originated in North America, *Diplocynodon* only has a fossil record in Europe, dating from the middle Eocene to middle Miocene (c. 45-15 Ma). The study of *Diplocynodon* remains curated in palaeontological collections could aid research on the morphology, phylogeny, evolution and biogeography of this large and widespread genus. We describe the *Diplocynodon* material in the historical Filhol collection of KU Leuven, collected at Saint-Gérard-le-Puy (early Miocene) and Ronzon (early Oligocene), from central France in the late 19th century. The aim was to identify which remains reside in the Filhol collection and to deduce the systematics behind these remains, making the collection more accessible to future research. A total of 781 skeletal elements were catalogued, including both cranial and postcranial bones. The most complete and anatomically representative specimens were photographed. Based on characteristic features, the remains from Saint-Gérard-le-Puy were confirmed as *D. ratelii*, a taxon that has previously been described from that locality. The remains from Ronzon could not be confidently determined in the present study.

Chen, Q., Guan, Q., Sun, J., Ying, D., Li, H., Li, P., Zhao, M. and Wu, C. (2026). Variation in soil metals, metalloids and bacterial communities in Chinese alligator habitat across different functional zone and soil depth. *Soil Systems* 10: 101.

Abstract: Soil metal contamination poses potential risks to ecosystem health, yet its vertical distribution and impacts on microbial communities in protected wildlife habitats remain poorly understood. This study investigated the vertical variation (0-80 cm) in seven metals or metalloids (Zn, Cr, Cu, Co, Ni, As, and Pb) and their correlations with soil bacterial communities in the Chinese Changxing Alligator Nature Reserve, Zhejiang Province, China. Soil samples were collected from two functional zones - the Reserved Breeding Zone (FY) and Reintroduction Zone (FG) - at four depth intervals. The results revealed distinct vertical stratification for both soil elements (metals and metalloids) and bacterial communities. Soil element concentrations exhibited depth-dependent variations, with surface layers showing higher accumulation of Zn, Ni, Cu, Cr and Pb, while As was enriched in deeper horizons. Bacterial alpha diversity declined with depth, and community composition shifted markedly: *Pseudomonadota* and *Actinomycetota* dominated surface soils, whereas *Acidobacteriota* and *Chloroflexota* increased in deeper layers. Network analysis revealed that microbial co-occurrence network complexity decreased with soil depth, indicating greater stability and environmental adaptability of surface soil microbial communities. Pearson correlation and Mantel analyses revealed significant depth-related variation in soil element concentrations (Zn, Co, Ni, Cu, Pb, Cr, and As), and these patterns were closely associated with shifts in soil bacterial community structure. This study provides systematic evidence of vertical differentiation in soil element-microbe interactions within reserve soil profiles, offering a scientific basis for habitat quality assessment, ecological risk warning, and Chinese alligator habitat conservation and management.

Karlowski, S., Prodromou, P., McCaskill, L. and Kouijzer, C. (2026). Capture bags for various species - from tiny birds to big crocs. The

Zoological Garden 94: 99-109.

Abstract: The physical capture of animals in zoological and wildlife settings is sometimes unavoidable (Miller & Fowler 2014), particularly during emergencies or when training-based handling is not feasible. However, conventional capture methods such as nets can cause significant stress, injury (Breed *et al.* 2019a), and entanglement, potentially leading to severe conditions such as capture myopathy (Spraker 1993; West *et al.* 2014). This article presents the development, testing, and application of innovative capture bags designed as safer and more humane alternatives to nets. Since 2020, various prototypes have been developed and evaluated across nearly 60 animal species, including birds, mammals, reptiles, and crocodilians. Three capture bag designs - the Window Capture Bag, the Silky Animal Capture Bag, and the Croc Bag - are described in detail. Results indicate reduced stress-related behaviour, absence of entanglement injuries, improved handler safety, and enhanced opportunities for training-based voluntary entry. These capture bags represent a valuable addition to existing animal-handling techniques, contributing to improved animal welfare and safer, more efficient capture procedures.

Lessner, E.J., Sherman, S.M., Petermann, H., Panigot, E., Duffy, F. and Lyson, T.R. (2026). New alligatorid, *Mandrasuchus milleri*, from the Early Paleocene (Danian) of the Denver Basin supports earliest Paleocene North American alligatorid radiation. *Journal of Vertebrate Paleontology*.

Abstract: The North American eusuchian fossil record through the Cretaceous-Paleogene (K-Pg) mass extinction shows a remarkable increase in diversity across the K-Pg boundary through the early Eocene. This is in contrast to most other vertebrate clades. Despite the group's uninterrupted existence across the K-Pg boundary, gaps remain in the alligatorid fossil record, particularly near the K-Pg boundary and geographically in Colorado. Here we describe a new alligatorid, *Mandrasuchus milleri*, gen. et sp. nov., from the lower Paleocene Denver Formation of Corral Bluffs, Colorado, represented by over 15 specimens. We identify a globidontan alligatorine by the globular caudal dentition and blunted rostrum. Regardless of precise taxonomic assignment, the alligatorid is stratigraphically the earliest confirmed alligatorine, with diagnostic crania from ~350 kyrs (Puercan 2 North American Land Mammal Age [NALMA]) and referred globular teeth from ~200 kyrs (Puercan 1 NALMA) post-K-Pg mass extinction. The alligatorine is a new representative of a largely unresolved portion of the crocodylian phylogeny, and its addition could help resolve relationships of early diverging alligatorids and taxa historically referred to *Allognathosuchus*. This taxon's distinct rostral morphology and globidont dentition suggest its ability to engage in a macrogeneralist diet. Dietary niche partitioning is likely present in this ecosystem as *M. milleri* lived alongside the generalist macrocarnivore *Borealosuchus sternbergii*, the other known Denver Formation crocodylian. The eusuchian survivorship across the K-Pg mass extinction and the morphological diversity of these apex freshwater predators underscores the degree to which freshwater terrestrial ecosystems were buffered from Earth's last mass extinction.

Florides, G.A. and Christodoulides, P. (2026). On dinosaur reconstruction: The body. *Open Journal of Geology* 16: 503-543.

Abstract: This is the fourth in a series of articles presenting the theoretical background for reconstructing dinosaurs in all scientific details, focusing on the body of *Amargasaurus cazaui*. Following the Extant Phylogenetic Bracket method, the musculature of the neck, pectoral girdle, forelimbs, hindlimbs and tail are reconstructed using comparative anatomy of extant archosaurs, primarily *Alligator mississippiensis* and *Crocodylus porosus*. The posture of the skeleton is critically evaluated against competing gait hypotheses, and a walking stance with the right forelimb and left hindfoot bearing the weight is adopted. The elongated neural

spines of the neck are reconstructed with a sail blending smoothly with the rest of the body. For a full-scale physical reconstruction, the bones are formed from welded steel wire rods assembled on a steel armature, with iron reinforced concrete columns and beams providing structural support. Muscles are built up using wire mesh and plaster guided by metal templates, and the skin is finished with rolling stamps producing polygonal scale rosettes. The completed model is a scientifically informed, full-scale representation of *Amargasaurus*, ready for exhibition. This work aims to promote understanding of past life on earth and to motivate interaction with the art of paleontology.

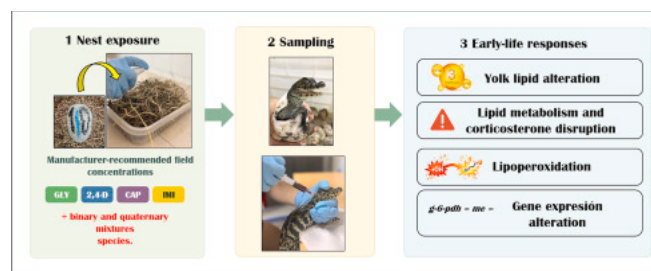
Lima dos Santos, R. (2026). Five decades of crocodilian ecotoxicology: a global scientometric analysis of environmental biomonitoring research. [Research Square](#).

Abstract: Crocodilians are valuable sentinel species for environmental biomonitoring because of their longevity, high trophic position, site fidelity, and capacity to bioaccumulate contaminants. This study presents a global scientometric assessment of crocodilian ecotoxicology by combining bibliometric analyses with a manually curated classification of ecotoxicological attributes. A PRISMA-based Scopus search retrieved 370 records, of which 187 publications from 1971 to May 2026 met the eligibility criteria. Bibliometrix, VOSviewer, and Python-based analyses were used to examine publication trends, conceptual structure, species, geographical distribution, contaminants, biomarkers, biological matrices, and study designs. Scientific production increased markedly after 2000. *Alligator mississippiensis* and *Caiman latirostris* were the predominant model species, while the United States, Argentina, Brazil, and South Africa were the principal research hubs. Species-level analyses associated *A. mississippiensis* mainly with heavy metals and endocrine disruption, *C. latirostris* with pesticide toxicology and multiple-biomarker approaches, and *Crocodylus moreletii* and *C. niloticus* with metals and persistent organic pollutants. The literature progressively shifted from contaminant quantification toward mechanistic and effect-based assessments. However, substantial taxonomic, geographical, and methodological gaps remain. These findings provide a global baseline for future biomonitoring, ecological risk assessment, and crocodilian conservation.

Chacón, C.F., Parachú Marcó, M.V., Rodríguez, F.M., Amweg, A.N., Siroski, P.A. and Poletta, G.L. (2026). Agriculturally relevant pesticide exposure scenario induces early-life lipid metabolism disruption and physiological stress in *Caiman latirostris*. [Chemosphere](#).

Abstract: Pesticide use in extensive agriculture generates complex exposures for wildlife, however, early-life effects in reptiles remain underexplored. In this study, we evaluated whether embryonic exposure at manufacturer-recommended concentration for field use: glyphosate (GLY at 1 and 2%), 2,4-D (at 0.06 and 0.12%), chlorantraniliprole (CAP at 0.015 and 0.03%), imidacloprid (IMI at 0.1 at 0.2%) and three mixtures at the lowest concentrations (M1: GLY+2,4-D; M2: CAP + IMI; M3: M1+M2) disrupt lipid metabolism, lipoperoxidation and corticosterone levels in *Caiman latirostris* hatchlings. Hatching success declined under 2,4-D 0.06%, CAP 0.03%, and IMI 0.2%. Residual yolk showed alterations in polyunsaturated fatty acids, together with yolk-cholesterol and α -tocopherol depletion, particularly under CAP 0.03% and in the complex mixtures M1, M2, and M3. Changes in plasma lipid profiles, hepatic aminotransferase activities as well as alteration of NADPH-producing gene expression in blood were observed in M2 and M3. Higher lipoperoxidation levels were observed at the highest concentration across single compounds and in M1 and M3; whereas corticosterone increased in 2,4-D 0.12%. These findings demonstrate that early life stages of caimans are highly sensitive to these xenobiotics, affecting lipid metabolism and associated physiological processes. Moreover, mixtures induced stronger and more complex

responses than single compounds, leading to metabolic disruption during early development. Our findings highlight the importance of evaluating realistic agrochemical mixtures to better assess their ecological risk.



Odetti, L.M., López González, E.C., Lorenzi, A.C., Simoniello, M.F. and Poletta G.L. (2026). Genotoxic effects of selected antiparasitic drugs in *Caiman latirostris*. [Journal of Basic and Applied Genetics XXXVII\(1\)](#).

Abstract: The Broad-snouted caiman (*Caiman latirostris*) is a reptile native to north-central Argentina and other countries in South America. Many populations are affected by habitat loss and modification associated with agricultural expansion. Livestock intensification has led to increased use of veterinary products, particularly antiparasitic drugs (APDs). These compounds may contaminate nearby soil and water bodies, posing a potential risk to caimans. The aim of this study was to evaluate the potential genotoxic effects of commercial formulations of albendazole, fenbendazole, and ivermectin in juvenile *C. latirostris*. A subchronic exposure was conducted over two months using 48 individuals, which were distributed into four treatments (12 individuals per group): a Negative Control (NC) treated with drinking water; a group exposed to albendazole (Zoovet 3.8% - 20 ng/mL), another exposed to fenbendazole (Zoovet 5% - 20 ng/mL) and a group exposed to ivermectin (Zoovet 1% - 10 ng/mL). At the end of the experiment, blood samples were collected from all individuals to assess genotoxicity through the micronucleus and nuclear abnormalities tests, as well as the comet assay (CA). The CA revealed significantly higher DNA damage in caimans exposed to ivermectin compared to NC. No significant differences were found for the other genotoxicity biomarkers in any of the exposed groups. This is the first study to assess the potential genotoxic effects of APDs in this reptile species. These findings highlight the potential environmental impact of ivermectin on ecosystems.

Odetti, L.M., López González, E.C., Lorenzi, A.C., Simoniello, M.F. and Poletta G.L. (2026). Efecto genotóxico de antiparasitarios seleccionados en *Caiman latirostris*. [Journal of Basic and Applied Genetics XXXVII\(1\)](#).

Resumen: El yacaré overo (*Caiman latirostris*) es un reptil autóctono del centro-norte de Argentina y otros países de Sudamérica. Sus poblaciones se ven afectadas por la pérdida y modificación del hábitat debido a la expansión agropecuaria. La intensificación ganadera introdujo un mayor uso de drogas de uso veterinario, especialmente antiparasitarios (APs). Estos compuestos pueden contaminar suelos y cuerpos de agua cercanos, representando un riesgo para los caimanes. El objetivo de este estudio fue evaluar los efectos genotóxicos potenciales de las formulaciones comerciales de albendazol, fenbendazol e ivermectina en juveniles de *C. latirostris*. Se realizó una exposición subcrónica durante dos meses a 48 individuos que fueron distribuidos equitativamente en 4 tratamientos (12 individuos en cada grupo): Control Negativo (CN) tratado con agua potable; un grupo expuesto a albendazol (Zoovet 3.8% - 20 ng/mL), otro a fenbendazol (Zoovet 5% - 20 ng/mL) y un grupo expuesto a ivermectina (Zoovet 1% - 10 ng/mL). Al finalizar el ensayo se tomaron muestras de sangre a todos los individuos para evaluar genotoxicidad a través de la prueba de micronúcleo y otras anomalías nucleares, y del ensayo cometa.

Los resultados indicaron un daño en el ADN significativamente mayor en los individuos expuestos a ivermectina en comparación con el CN. No se encontraron diferencias significativas en el resto de los marcadores de genotoxicidad en los grupos expuestos. Este es el primer estudio en evaluar los posibles efectos genotóxicos de los AP en esta especie de reptil. Los resultados obtenidos nos alertan sobre el potencial impacto de la ivermectina en nuestros ecosistemas.

Benansio, J.S., Damaya, G.S., Okorie, I.E. and Nadarajah, S. (2026). Seasonal Nile crocodile damage to fishing gear, incident reporting and livelihood responses in the Sudd Wetlands, South Sudan. *Animals* 16: 2826.

Abstract: Wetlands support fisheries and other livelihoods but can also bring people into close contact with crocodilians. Human-crocodile conflict has been documented across Africa, Asia, Australia and the Americas, yet indirect economic costs, including damage to fishing gear, remain less studied than attacks on people or livestock. We analysed questionnaire data from 379 respondents in purposively selected crocodile-exposed fishing communities in the southern Sudd Wetlands, South Sudan. The study quantified seasonal patterns of Nile crocodile (*Crocodilus niloticus*) damage to fishing gear, reporting pathways, conflict-resolution perceptions, responses to damaged gear and likely annual damaged-net categories. Reporting pathways were defined as the social and institutional channels through which respondents said gear-damage incidents were communicated; handling responses were defined as actions taken after gear was damaged. As expected from seasonal variation in floodplain use, the water level and fishing activity, reported damage was concentrated from July to December, with September the being most frequently selected main damage month (157 respondents; 41.4%). Quarterly ordinal responses differed among seasons (Friedman test: $\chi^2 = 721.54$, $df = 3$, $p < 0.001$). Cumulative link models that included both quarters and the broader survey area showed the largest odds-ratio contrasts for July-September and October-December, whereas broader-area contrasts were smaller, and their confidence intervals overlapped one. Reporting was dominated by informal and community pathways: fishing-camp leadership, family members and other fishers each reached 100% agreement, whereas wildlife authorities received no affirmative reporting. Respondents also expressed little confidence in formal conflict resolution: 100% agreed that crocodile-related gear-damage conflicts were difficult to resolve, and 0% agreed that government would compensate for damaged gear. Damaged nets were mainly abandoned and replaced; repair was rare (1.6%). The most likely annual damaged-net category was 1-5 nets/year/participant (275 respondents; 72.6%). Because the survey was purposive, the results should be interpreted as patterns among sampled respondents and locations, not as prevalence estimates for all fishers in the Sudd Wetlands or South Sudan. The findings indicate that seasonal gear damage, weak formal reporting to wildlife institutions and limited institutional confidence should be central considerations in crocodile-conflict management.

Sharma, S.P., Hussain, S.A., Ghazi, M.G., Badola, R. and Hussain, S.A. (2026). Genomic signatures of ancient and recent population decline in the Critically Endangered gharial (*Gavialis gangeticus*). [BMC Genomic Data](#).

Abstract: The Gharial (*Gavialis gangeticus*) is a freshwater crocodylian endemic to the Indian subcontinent that has experienced ancient and recent catastrophic declines in population size. Conservation interventions initiated in the mid-1970s have enabled partial recovery of the species. Yet, how ancient and recent demographic declines have shaped contemporary genomic diversity in gharial remains unknown. Here, we present the first genome-wide analysis of the Gharial using a single high-coverage whole-genome sequence and ddRAD data from 21 individuals sampled across five nesting sites along the Chambal River. Our results reveal extremely low genomic diversity in the largest Gharial population,

with Watterson's $\theta = 0.0008 \pm 0.0001$ (mean $\pm$ SD) and Nucleotide diversity = 0.00036 ± 0.00005 , both substantially lower than those reported for other extant crocodilians. Analyses of population genomic structure indicated weak, partially resolved structuring, with individuals from Radi forming a distinct group, whereas individuals from other sites showed limited spatial structuring. Demographic reconstructions revealed declines in effective population size across multiple timescales, including an ancient decline occurring $\sim 10,000$ years ago and a more recent severe decline within the last ~ 250 years. Consistent with this recent decline, long ROH suggest that recent close inbreeding (~ 4 generations), rather than ancient demographic history alone, is the primary contributor to contemporary genome-wide homozygosity. Overall, these findings reflect both deep-time demographic constraints and ongoing genetic erosion in gharial, providing a critical foundation for genomics-informed conservation planning.

Hussain, S.A., Sharma, S.P., Panda, A.K., Usmani, A.A., Das, G.C., Mahar, N., Rawat, A.P., Sarkar, A., Gangaimaran, P., Ugemuge, S., Ali, S.Z., Barthwal, S. and Badola, R. (2026). Recovery of the Critically Endangered gharial (*Gavialis gangeticus*) amid escalating anthropogenic pressures in the Ganga River Basin. *Frontiers in Conservation Science* 7: 1920905

Abstract: The Gharial (*Gavialis gangeticus*) is a Critically Endangered, river-specialist crocodilian whose recovery in the Ganga River Basin has depended on decades of population augmentation and habitat protection, yet a basin-wide assessment of its current status has been lacking. The Gharial, endemic to the Indian subcontinent, has undergone a severe population and range decline through the mid-20th century (c. 1940s-1970s), driven by hunting, habitat loss, and incidental mortality in fishing gear. Conservation initiatives launched in the mid-1970s have contributed to its sustained recovery from the brink of extinction. Nevertheless, information on the current population status, habitat condition and long-term recovery trajectory is lacking. Boat-based surveys were conducted across 22 rivers covering 7680 km (60.3% of the total river length of 12,741 km) to determine the minimum population size (MPS) of Gharial in the Ganga River Basin. We recorded 3037 Gharials in 13 rivers, with the highest number from the Chambal (MPS = 2097), followed by the Ghaghra (MPS = 463) and Girwa rivers (MPS = 158), while less than 10 individuals were observed in the Sharda, Kosi, Bagmati, and Babai Rivers. Across 13 Gharial occupied rivers encounter rates ranging from 0.02 ± 0.01 ind./km (Ganga) to 7.90 ± 4.29 ind./km (Girwa), highest in Chambal (5.18 ± 0.50 ind./km) and lowest in Ganga and Kosi (≤ 0.02 ind./km). The Chambal, Gandak, and Ghaghra Rivers had individuals from all size classes, with a high proportion of larger individuals (> 1.8 m) in the population. Habitat suitability analysis revealed a large proportion of the river length the remaining 10,800 km (84.8%) have low predicted relative suitability. Only 1320 km (10.3%) was classified as highly suitable. Long-term data is from the Chambal population-trend analysis and is not extrapolated to the wider Ganga Basin, where our own river-wise survey data show a markedly uneven population status. Growth was most rapid during the initial intensive 'grow-and-release' phase from 1979 to 1993 (15.6% per annum). The identified river stretches potentially represent priority sites for the ongoing restocking program for Gharial, therefore requiring immediate conservation measures to support Gharial recovery in the Basin.

Warwick, C., Steedman, C. and Grant, R. (2026). Crocodylian welfare in irregular and unconventional facilities. [Journal of Veterinary Behavior](#).

Abstract: Crocodylians (crocodiles, caimans, alligators, and gharials), are utilized for skin, meat, and curios, and variously in traditional zoo and other live exhibit and entertainment situations. This study focuses on the use of crocodiles particularly in irregular and unconventional facilities, including mobile zoos, roadside

zoos, itinerant pet markets or expos, restaurants, and miniature golf courses within the southern United States (US). These situations can differ from established traditional zoos and some commercial farms. We gathered information regarding the prevalence of these facilities, as well as their operational characteristics. We performed a survey of formal regulators and a rapid evidence assessment targeting 10 southern US states, and conducted general internet searches for crocodylians in such target facilities. We analysed both peer-reviewed scientific and grey literature to itemise documented concerns, which identified a dearth of material, but affirmed the presence of at least 47 potentially relevant facilities across four states. We provide essential scientific evidence-based husbandry guidance for crocodylians across diverse captive conditions in the interests of animal welfare, as well as an adjunct welfare assessment protocol.

Yoo, J., Qing, C., Penn, J., Fannin, J.M. and Stannard, C. (2026). Crafter preferences for alligator leather in an online hypothetical and real discrete choice experiment. *Journal of the Agricultural and Applied Economics Association* 5: 262-279.

Abstract: A decrease in the price of alligator hides has led to identifying new markets for wild alligator leather. This study investigates crafters' preferences for using alligator leather as a crafting material. In an online survey, we implement hypothetical and real Discrete Choice Experiments to assess crafters' willingness to pay for alligator craft kit items and characteristics of alligator leather. Results indicate crafters do not significantly discount scars as industry, revealing a market opportunity for scarred alligator leather products. We observe especially large hypothetical bias in willingness to purchase kits versus past studies, but little hypothetical bias for attributes.

Thanoi, P., Saenghong, K. and Lauprasert, K. (2026). Ontogenetic changes in the endocast and endosseous labyrinth of the Siamese freshwater crocodile (*Crocodylus siamensis* Schneider, 1801) from Thailand. *Zoological Studies* 65: 42.

Abstract: Ontogenetic changes in the brain and sensory systems play an essential role in shaping behavioral performance and ecological specialization in vertebrates; however, these developmental pathways are inadequately recorded in endangered crocodylians. Here, we present the first quantitative analysis of endocast and endosseous labyrinth development across ontogeny in the Siamese freshwater crocodile (*Crocodylus siamensis*), a critically endangered species from Southeast Asia. Using high-resolution computed tomography (CT) and three-dimensional reconstruction, we examined six skulls representing juvenile, subadult, and adult growth stages. Our findings reveal a consistent pattern of allometric scaling, correlated with marked morphological changes in sensory-related neuroanatomical structures. Juveniles display strongly curved forebrains and proportionally prominent olfactory regions, which is in line with their early reliance on chemosensory cues. As skull size increases, the encephalic endocast becomes longer and straighter, while regions corresponding to the midbrain and hindbrain show proportional morphological changes associated with visual processing and motor coordination, suggesting ontogenetic changes in regions associated with visual processing and motor coordination. Parallel ontogenetic transformations are also observed in the endosseous labyrinth, including increased lagena dimensions and more pronounced semicircular canal curvature in adults. These changes are consistent with ontogenetic variation in structures associated with auditory and vestibular functions. Strong correlations between dorsal cranial length and both endocast and labyrinthine parameters suggest that sensory-related neuroanatomical morphology in *C. siamensis* follows a consistent ontogenetic scaling pattern. These findings establish an important neuroanatomical baseline for understanding sensory ecology in this endangered crocodylian and provide a comparative framework for interpreting fossil crocodylian neuroanatomy, with implications for

conservation biology, functional morphology, and paleoneurology.

Jayasinghe, A.D., Burns, G.L., Nalau, J. and Biggs, D. (2026). Human-wildlife coexistence and social context: Evidence from farmer communities in southern Sri Lanka. *People and Nature*.

Abstract: Studies on human-wildlife interactions (HWI) often focus on conflict mitigation studies, thus overlooking underlying factors that influence community decisions to coexist with wildlife. To address this knowledge gap, we collected empirical evidence of how community interactions with wildlife are shaped by their social contexts. In this study, values, norms and knowledge are referred to as the social context of communities that influence human-wildlife coexistence (HW-coexistence). Through an ethnographic study consisting of focus group discussions and transect walks inside the Walsapugala village in southern Sri Lanka, we show how the social context of farmer communities influences their interactions with wild elephants. Our study revealed seven key themes, which influence HW-coexistence: (1) Community strength and social cohesion; (2) Ethical stewardship and emotional connection; (3) Cultural inheritance; (4) Social dynamics and group interactions; (5) Ethical integrity and social critique; (6) Community learning and practices; and, (7) Multi-dimensional awareness. By highlighting the social context of the participating communities, these themes can guide designing effective conservation programmes. Therefore, we recommend further longitudinal and qualitative research to increase understanding of the nuances of community interactions with wildlife.

Obuse, S. and Shibata, M. (2026). New goniopholidid specimens from the Lower Cretaceous Kitadani Formation, Tetori Group, Japan. *Annales de Paléontologie* 110 (2024): 102661.

Abstract: New crocodyliform fossils have been discovered from the Lower Cretaceous Kitadani Formation of the Tetori Group, Fukui, Japan. They include skull elements (premaxilla, maxilla, parietal, quadrate and dentary), postcranium elements (dorsal vertebra, caudal vertebra, femur and osteoderm) and isolated teeth, and are described as goniopholidid crocodyliforms. Phylogenetic analysis resulted in nesting the Kitadani goniopholidid at the basal position of Goniopholididae and one autapomorphy is recognized: presence of the parietal sagittal crest. In addition, the narrow snout and a heterodont dentition in jaws of this goniopholidid is a unique combination of rostral morphology among Goniopholididae. Generally, the basal taxa bear a narrow snout with homodont dentition, and the heterodont dentition is seen in derived broad-snouted taxa. Judging from those rostral shape and dentitions, the Kitadani form possessing acute caniniform and blunt teeth tends to be more opportunistic as foraging strategy than other basal narrow-snouted goniopholidids with only acute caniniforms throughout. Our new discovery is the first osteological report of Japanese Cretaceous crocodyliform. *Siamosuchus phuphokensis* from the Early Cretaceous Sao Khua Formation, Khorat Group also shows combination of basal and derived cranial characters. Transitional species from Asia suggest allopatric speciation of goniopholidid in geographically intermediate Asian area.

Liu, M., Wang, S., Wei, J., Sun, K., Zhou, Y., He, J., Nie, H., Lu, L., Li, E. and Wu, X. (2026). 2D structural annotation and 3D reconstruction of the whole brain of *Alligator sinensis*. *Anatomical Record*.

Abstract: The Chinese alligator (*Alligator sinensis*) is a small crocodylian endemic to China; current neuroanatomical knowledge of its whole brain remains limited. In the present study, we combined the Micro-Optical Sectioning Tomography system with Imaris, CorelDRAW, and MATLAB software to generate a histological atlas of the entire Chinese alligator brain and reconstruct its 3D digital brain model. Results showed that the whole brain of the Chinese alligator

is anatomically partitioned into eight major compartments: olfactory bulb (OB), olfactory tract (OTr), telencephalon (Tel), diencephalon (Dien), mesencephalon (Mes), cerebellum (Cer), pituitary gland (PG), and medulla oblongata (MO). Most distinguishable cytoarchitectonic structures reside within the Tel, Dien, and Mes. The main OB exhibits a finely laminated cytoarchitecture, whereas an accessory olfactory bulb (AOB) is absent. Collectively, the Tel and Dien occupy approximately one-third of the total brain volume. The mesencephalic tectum displays distinct laminar organization, with the corpora quadrigemina (CQ) differentiated into superior and inferior colliculi. A total of 116 discrete brain structures were annotated in this atlas. We unambiguously identified a pineal body (PB) in the Chinese alligator, substantially expanding the fundamental neurohistological dataset of crocodilian brains. This work establishes a foundational morphological template for reptilian nervous system research and provides critical comparative anatomical references for evolutionary neurobiology across all vertebrate lineages.

Hoffman, D.K., Nicholl, C.S.C., Bradley, O., Magar, S., Sebaratnam, M.S., Houssaye, A., Felice, R.N., Yates, A.M., Poropat, S.F. and Mannion, P.D. (2026). Osteohistological evidence for terrestrial adaptation and an extended growth period in mekosuchine crocodylians and its potential role in their extinction. [Anatomical Record](#).

Abstract: The Australasian crocodylian fossil record is dominated by the extinct endemic clade Mekosuchinae, with known members spanning the Eocene-to-Holocene. This diverse clade exhibited high morphological disparity, from early members superficially similar to *Crocodylus*, to more terrestrial forms later in the clade's evolutionary history. However, it remains unclear why mekosuchines went extinct whilst *Crocodylus* continues to thrive in the region, and how the ancestors of this terrestrial clade reached Australasia without long-distance transoceanic dispersal. One possible explanation is that there was intraclade variation in the growth pattern and life habit of mekosuchine species, and that these, in turn, differ from those of *Crocodylus*. Here, we present the first osteohistological study of mekosuchines, evaluating the femora of the middle-late Eocene species *Kambarata taraina* and late Oligocene-middle Miocene *Baru* (*B. wickeni*, *B. darrowi*). Bone compactness profiles are more characteristic of a terrestrial habit than those of extant crocodylians, with *Baru darrowi* demonstrating the most terrestrialized profile. Apposition rates are similar in absolute value to those of extant crocodylians, indicating a comparable metabolism; however, high appositional rates throughout mid-cortical cyclical growth marks suggest that mekosuchines were able (or needed) to maintain a moderate rate of growth for longer than extant crocodylians. Our results indicate that mekosuchines were more terrestrial than *Crocodylus* and that later-diverging mekosuchines showed increased terrestrialization; however, they do not indicate that early mekosuchines were well-adapted to transoceanic dispersal. Heightened terrestrialization and an extended moderate growth period might have made mekosuchines more vulnerable to late Cenozoic aridification in Australia than semi-aquatic *Crocodylus*.

de Menezes Costa, J.V., Azevedo, L.P., Pressinotti, L.N., de Melo Reis, E., Lima Deluque, A., Mesquita Pucca, F., Bassi Branco, C.L., Vandresen-Filho, S. and Rios-Santos, F. (2026). *Caiman yacare* oil enhances endocytic activity without triggering oxidative or nitrosative stress in murine macrophages. *Revista Brasileira de Farmacognosia* 36: 92.

Abstract: In recent years, the search for immunomodulatory compounds derived from natural sources has increased. *Caiman yacare* visceral fat oil has shown promise because of its complex lipid profile and potential anti-inflammatory properties. This study evaluated the cytotoxicity, redox behavior, nitric oxide release, and endocytic capacity of murine macrophages treated with *C. yacare* visceral fat oil. J774A.1 macrophages were exposed to

different concentrations of oil. Cell viability was assessed using the 3-(4,5-dimethylthiazol-2-yl)-2,5-diphenyltetrazolium bromide (MTT) assay; reactive oxygen species and nitric oxide production were evaluated by flow cytometry and the Griess reaction, respectively. Phagocytosis and pinocytosis assays were performed using fluorescein isothiocyanate (FITC)-labeled *E. coli* and neutral red uptake. *Caiman yacare* visceral fat oil was non-cytotoxic at concentrations up to 250 µg/ml. No increases in intracellular reactive oxygen species and nitric oxide production were observed. *Caiman yacare* visceral fat oil significantly inhibited nitric oxide release from lipopolysaccharide-stimulated macrophages and enhanced phagocytosis at all tested concentrations. Pinocytosis was significantly increased at 50 µg/ml. *Caiman yacare* visceral fat oil exhibited immunomodulatory potential by attenuating lipopolysaccharide-induced nitric oxide release while enhancing phagocytic capacity, supporting its potential as a natural immunopharmacological agent.

Mukherjee, S. (2026). Opportunistic predation on a Little egret (*Egretta egretta*) by a captive Gharial (*Gavialis gangeticus*) at the Madras Crocodile Bank, India. *Reptiles & Amphibians* 33: e23755.

Loker, E.S., Brant, S.V., Lu, L. and Laidemitt, M.R. (2026). From Bilharz's twig to thriving tree: Revealing the diversity of blood flukes. [Parasitology Research](#).

Abstract: Bilharz's discovery in 1851 of the first fluke formally known to live within blood vessels initiated a very much ongoing process of discovery involving many investigators that today recognizes a blood fluke Superfamily Schistosomatoidea containing 13 families and about 95 genera. Feeding on vertebrate blood is a trait they likely inherited from common ancestors with polyopisthocotylean monogeneans, recently recognized as the sister group to the trematodes. A case has been made for considering the blood flukes to be the primordial digeneans, not only because of pre-adaptations acquired from polyopisthocotylean-like ancestors, but for other reasons as well, including their 2-host life cycles and broad patterns of host usage. Blood fluke adults are found in an unparalleled spectrum of definitive hosts, ranging from chondrichthyans, acipenseriforms, teleosts, turtles, crocodilians, and birds and mammals. Eggs produced by adult blood flukes are striking in their diverse shapes and collectively vary over an order of magnitude in size. Blood flukes also infect a greater diversity of first intermediate hosts - marine polychaete annelids, marine bivalves and a broad variety of gastropods - than any other digenean group. Their larval stages are also diverse, ranging from small, ovoid daughter sporocysts or rediae producing few cercariae, to amorphous daughter sporocysts that produce prodigious numbers of cercariae. Blood fluke cercariae range from nearly tailless non-swimming forms to forms with partially forked tails to cercariae with long forked tails well-adapted to penetrate host skin. Additionally, members of the Schistosomatidae exhibit dioecy, and have subsequently evolved a variety of alternative egg-laying strategies, bringing us back to Bilharz's seminal discovery, of a schistosome unique or nearly so among the entire superfamily for predictably ovipositing in the bladder wall. Additional discoveries and surprises await.

Tomcho, A.L. (2026). Stable Isotope Analysis of American Alligator (*Alligator mississippiensis*) Tooth Enamel: Establishing a Contemporary Framework for Distinguishing Coastal and Inland Habitats in the Paleontological and Archaeological Records of Southeastern North America. MSc thesis, University of North Georgia, Athens, Georgia, USA.

Abstract: Stable carbon ($\delta^{13}\text{C}$), oxygen ($\delta^{18}\text{O}$), and strontium ($^{87}\text{Sr}/^{86}\text{Sr}$) isotope values were measured in tooth enamel of 18 American alligators (*Alligator mississippiensis*) from coastal (n= 12) and inland (n= 6) habitats of Georgia, South Carolina, and Florida to establish a framework for habitat discrimination

applicable to ancient crocodilian material. $^{87}\text{Sr}/^{86}\text{Sr}$ differed between coastal (0.70895) and inland (0.71156) individuals ($p < 0.001$), with values falling into three ranges reflecting regional bedrock geology. Coastal individuals were enriched in mean $\delta^{13}\text{C}$ values (-10.63‰ vs. -15.65‰ ; $p = 0.002$). Within the coastal group, intra-tooth $\delta^{18}\text{O}$ standard deviation was higher in hydrologically open than isolated habitats ($p < 0.01$), tentatively suggesting an influence of hydrological connectivity. Mean $\delta^{18}\text{O}$ values did not differ between groups. These data provide a framework for better understanding the dynamics of Pleistocene and Holocene paleoshorelines and paleoenvironments in southeastern North America.

Rask-Andersen, H., Melkersson, K.-G., Staxäng, K., Hodik, M., Andersson, E.R. and Li, H. (2026). Re-building inner ear hair cells and why crocodiles hear so well. [Paper 125](#) in Proceedings of the Baltic-Nordic Acoustics Meeting, Gothenburg, Sweden, 2-6 May 2026.

Abstract: The vulnerable human inner ear contains only 3400 inner ear cells that show little sign of regeneration. This compares to the eye containing about 126 million photoreceptors to convert light into nerve signals. Reptiles such as crocodiles may effectively replace lost inner ear hair cells (Li *et al.* 2022) and do not lose hearing despite reaching considerable age. Can we learn from them which mechanisms are involved in the regeneration of their sensory cells? A multidisciplinary group consisting of molecular biologists, reptile specialists, ear researchers and electron microscopists joined into a formal group named “Swedish Crocodile Research Group” (SCRG) (Li *et al.* 2022, 2023; Melkersson *et al.* 2024, 2026). We aim to learn more how animals showing unique regenerative properties have evolved these abilities, to re-build not only inner ear sensory cells but also other organ cell systems, to regain function. We wish to identify the genes activated at damage, and their programs that start regeneration. To test if these genes can drive formation of new hair cells and regeneration in mammals including testing causality via in utero genetic perturbations (de Haan *et al.* 2025). How this can lead to new gene therapies directed on supporting cell division changing identity to become functional hair cells and also other organs? The final goal to achieve is - how humans can maintain hearing throughout life - using evolution's own instructions!

Cruise, A. (2026). The myth of human-wildlife conflict: Why wildlife is not the problem reframing wildlife governance through the ethics of coexistence. In Proceedings of the 4th Annual Colloquium on Animal Welfare, Human Rights, Rights of Nature, and Human-Wildlife Coexistence, Potchefstroom, South Africa.

Abstract: Conflict is one of the most powerful words in conservation. It shapes legislation, management plans, research priorities, funding decisions and public attitudes. Once an interaction is labelled a conflict, the search for a solution begins. Yet surprisingly little attention is paid to the more fundamental question: what, exactly, is in conflict? For decades, human-wildlife conflict has been a dominant paradigm through which conservationists, policymakers and wildlife managers understand difficult interactions between people and wild animals. The concept appears self-evident. Elephants damage crops. Predators kill livestock. Baboons enter homes. Crocodiles injure and sometimes kill people. These events can impose genuine economic, physical and emotional costs, and nothing in the argument that follows seeks to diminish them. What I question is something different: whether describing these interactions as human-wildlife conflict correctly identifies either their origins or the appropriate object of management. My central argument is that wildlife is seldom the underlying cause of what we call human-wildlife conflict. Conflict emerges from the ways human societies organise landscapes, distribute resources, establish property relations, construct legal categories and determine what constitutes acceptable animal behaviour. Wild animals respond to ecological opportunities and constraints. Humans decide when those responses become unacceptable. This distinction is important because the

diagnosis determines the treatment. If wildlife is understood as the problem, wildlife becomes the object of intervention. We fence, deter, translocate, sterilise, contain and kill. If, however, many of these interactions arise from human decisions about land, infrastructure, waste, agriculture and protected-area boundaries, then our conventional approach has the problem backwards. We have become extraordinarily sophisticated at managing animals while remaining remarkably resistant to managing ourselves. This paper therefore asks whether conservation should move beyond the paradigm of conflict management towards something more demanding: governing for wildness. Such an approach would begin not by asking how wildlife must change to accommodate human society, but how human institutions must change if wild animals are to continue living as wild beings within increasingly shared landscapes.

Utete, B. (2026). Traditional water knowledge and Nile crocodile (*Crocodylus niloticus*) conservation in southern Africa: A systematic review of policy integration, institutional gaps, cultural uses, and barriers. *Frontiers in Conservation Science*.

Abstract: The Nile crocodile (*Crocodylus niloticus*) is classified as of Least Concern on the IUCN Red List. As apex predators, crocodiles play vital ecosystem clean up roles. However, anthropogenic activities threaten its population in wetlands in Southern Africa. The species attracts significant interest from humans within the Traditional Water Knowledge (TWK) ambit. This Preferred Reporting Items of Systematic Reviews and Meta-Analyses (PRISMA) guided review assessed the uses of crocodiles, inclusion levels, and barriers and benefits of integrating TWK in Southern African Development Community (SADC) countries' wildlife and water policies for crocodile conservation. TWK poses an existential threat to crocodile conservation through intergenerational negative perceptions bordering on myths and ethno zoological medicinal use incorporating its eyes, tail, head, scales, gall bladder, belly skins, liver and bile duct secretions. Anthropogenic driven destruction of nesting sites abetted by poor monitoring of wetland habitats by wildlife authorities cause declines in populations and shifts in distribution. Crocodile ranching is effective to sustain populations of crocodiles though its reliance on wild egg collection for enhancing production negates its overall contribution to conservation. TWK is poorly conceptualised and covered in wildlife and water conservation policies in SADC. Integrating geospatial techniques and citizen science in TWK provides a holistic framework to conserve crocodile populations in Southern Africa.

Furness, A.I. (2026). Lunge feeding in the American alligator (*Alligator mississippiensis*). *Reptiles & Amphibians* 33: e24066.

Fan, Y., Pan, T., Dussex, N. and Lan, T. (2026). Captive breeding of the Chinese alligator reduces inbreeding but increases genetic load. [Integrative Zoology](#).

Abstract: Inbreeding depression is a major threat to the long-term viability of small populations. Although captive breeding and genetic rescue are the main alternative in conservation, their genomic impacts are largely unknown, and the unintended effects of these approaches may intensify the depression by introducing new deleterious mutations. Based on whole-genome sequencing data from 247 critically endangered Chinese alligators, we constructed a high-resolution genetic variation map and identified three distinct genetic populations, clarifying their demographic history and further supporting the independent origin of the American population. Comparisons between captive and semi-wild populations revealed that captive management outperforms semi-wild management in reducing inbreeding and increasing genetic diversity, while simultaneously elevating the accumulation of deleterious mutations, which may result from relaxed purifying selection. Although the inbreeding coefficient in this species is notably higher than in other

endangered species, purging has likely played a significant role in reducing the amount of recessive deleterious mutations. Forward-in-time simulations indicated that mixing populations can mitigate the risk of demographic decline, yet current populations still remain vulnerable to future environmental changes. These findings provide valuable genomic evidence to guide balanced and effective conservation strategies for the Chinese alligator.

Xu, G., Zhang, J., Zhao, W. and Yu, Z. (2026). Immunomodulatory mechanism of the crocodile-derived peptides AKLDLEEVK and DFLDLPSIER mediated by macrophage metabolic reprogramming. *Food Bioscience* 85: 110065.

Abstract: Crocodile has long been utilized as a traditional high-protein food resource and is recognized as a rich source of health-promoting bioactive peptides. Previously, we identified two immunomodulatory peptides, AKLDLEEVK (AK-10) and DFLDLPSIER (DR-10), from crocodile head protein hydrolysates, which enhanced basal immunity function and suppressed inflammatory responses under distinct immune microenvironments. However, the underlying mechanisms remain unclear. This study investigated the mechanism by which adaptive metabolic reprogramming mediates the effects of AK-10 and DR-10 on macrophage phenotype and function in resting and LPS-induced inflammatory microenvironments. The results showed that AK-10 and DR-10 triggered metabolic reprogramming adapted to the immune microenvironment, with loss-of-function experiments confirming that these metabolic shifts are required for macrophage phenotypic polarization and functional shifts. Under resting conditions, both peptides enhanced glycolytic flux and upregulated the mRNA expression of HK2, PKM2, and LDHA, providing metabolic support for M1 polarization, which in turn promoted the expression of CD86, iNOS, and pro-inflammatory cytokines, thereby enhancing basal immune surveillance. Under inflammatory stress, they suppressed aberrant glycolysis and restored oxidative phosphorylation, accompanied by upregulation of PGC-1 α , CPT1a, and CS mRNA expression. This metabolic transition drove macrophage polarization from M1 toward the anti-inflammatory M2 phenotype (elevated CD206, Arg-1, IL-10, TGF- β), thereby exerting anti-inflammatory effects. Moreover, AK-10 and DR-10 regulated intracellular ROS levels and enhanced antioxidant defense capacity, thereby maintaining redox homeostasis. Collectively, these findings reveal the metabolic mechanisms by which AK-10 and DR-10 orchestrate macrophage immune responses across distinct immune microenvironments, suggesting a potential basis for their application as functional food ingredients.

Huang, S., Zhang, L., Liu, F., Zhang, Z., Liang, B., Hu, X. and Wang, X. (2027). Reptile new insights into the molecular mechanisms underlying temperature-dependent sex determination. *The Innovation Life* 5: 100252.

Srikulnath, K., Panthum, T., Saensong, D., Singchat, W., Suksavate, W., Chaiyes, A., Paansri, P., Faikhamta, C., Obidiegwu, A., Duengkae, P. and Tamsiripong, Y. (2026). Reclaiming the restoration frontier: regional framework for the recovery of the Siamese crocodile driven by genomic integrity and climate refugia. [Endangered Species Research](#).

Abstract: The critically endangered Siamese crocodile *Crocodylus siamensis* presents a profound conservation paradox: while abundant in commercial farms, it remains functionally extinct in nature, requiring a restoration roadmap that integrates genomic integrity with science-led spatial recovery. Although Thailand maintains a crocodile population of over 1.2 million individuals in commercial farms, this captive reservoir represents a genetic chimera that is severely compromised by widespread captive interspecific hybridization with *C. porosus* and *C. rhombifer* in Thai crocodile farms. To address this paradox, we propose a

multidisciplinary recovery roadmap that integrates MaxEnt, an algorithm for modeling species distribution, with rigorous “genetic gatekeeping” protocols developed by Kasetsart University. By synthesizing 244 historical occurrence points, derived from linguistic fossils, specifically village toponyms such as “Chorakhe” or “Takhay”, with modern environmental variables, this review transforms cultural memory into a functional “ghost map” for identifying high-suitability refugia. The validity of this framework is substantiated by two transformative breakthroughs: the successful release of DNA-verified purebred individuals into Kaeng Krachan National Park and the expansion of head-starting protocols, which have reduced natural hatchling mortality from 90% to less than 5%. Our review demonstrates that combining AI-driven risk prediction, acoustic telemetry, and community-based “Crocodile Guardians” can effectively mitigate human-wildlife conflict while restoring the ecological role of the species as a keystone predator. By bridging the gap between a 250-million-year evolutionary lineage and modern genomic science, this study provides a scalable, high-impact model for species restoration across Southeast Asia.

Jarosz, A. (2026). Crocodile mummification in ancient Egypt: A comparative taphonomic analysis of the natural and intentional preservation of remains (in Polish). *Studia Antiquitatis et Medii Aevi Incohantis Supplement* 2: 8-19.

Abstract: This article presents the results of an analysis of crocodile mummies based on the literature and photographic materials. The developed typology of the remains reveals both differences and similarities between natural and intentional mummification. Additionally, the paper addresses changes in mummification processes and the significance of the god Sobek in ancient Egyptian religion. The analysis also outlines directions for further research.

Pritz, M.B. (2026). Development of thalamo-telencephalic circuits in a reptile. *Journal of Comparative Neurology* 534(10): e70203.

Abstract: Neuronal circuits are a core component required for proper brain function and organization. How these circuits are built remains incompletely understood. The vast majority of studies on forebrain development have investigated mammals. Whether the described observations found in mammals apply to other vertebrates is unknown. The present report examined the development of forebrain circuits that interconnect the dorsal thalamus and the telencephalon in *Alligator mississippiensis*. A tracer, neurobiotin, which is transported in both an anterograde and retrograde fashion, was used. Four circuits were identified after neurobiotin placement into either the diencephalon or in the forebrain bundles themselves. Three circuits ascended from the dorsal thalamus to the telencephalon. These were: the ipsilateral lateral forebrain bundle and the ipsilateral and contralateral medial forebrain bundles. The other circuit descended from the basal nuclei to connect with the dorsal thalamus. The first circuit to develop was the basal nuclei to dorsal thalamus circuit followed by the lateral forebrain bundle and lastly by the medial forebrain bundle. Because it preceded the formation of the three other circuits, the basal nuclei to the dorsal thalamus tract is suggested to serve as a scaffold for the other three circuits to follow. The formation of synapses by lateral forebrain bundle axons in the telencephalon was determined by immunohistochemistry using a synaptic vesicle glycoprotein. Synapse formation in the telencephalon from lateral forebrain bundle axons occurred before hatching. This suggested that information carried by the lateral forebrain bundle was critical for survival upon hatching. Medial forebrain bundle axon connections may become functional only after hatching.

Mukherjee, D. and Vijay, M. (2026). A review on why some of the reptilian lineages are relict taxa? *International Journal of Science and Research* 15(8): 1737-1742.

Abstract: The Earth has never remained environmentally or geologically stable since its origin. Plate tectonics, continental drift, climatic oscillations, sea-level fluctuations, geological catastrophes and associated ecological changes have repeatedly altered the distribution, diversification and extinction of several organisms. These processes have profoundly influenced the evolutionary history and biogeography of the so-called Class Reptilia. Nevertheless, several extant reptilian lineages represent highly distinctive remnants of formerly more diverse and geographically widespread evolutionary radiations. Such taxa are commonly referred to as evolutionary or phylogenetic relicts. The present review reveals why some reptilian lineages have remained comparatively conservative in their fundamental morphology while other reptilian taxa have undergone extensive diversification and innovation of morphologically novel traits. Particular attention is given to the tuatara (*Sphenodon punctatus*), phylogenetically primitive monitor lizard (lack of exposed external tympanum), *Lanthanotus borneensis* and the Gharial (*Gavialis gangeticus*) as examples of evolutionarily distinctive and unique surviving monotypic lineages, taxonomically known as monotypic taxa. The review discusses phylogenetic conservatism and ecological constraints with respect to niche segregation, ecological specialization, stabilizing selection, developmental as well as functional constraints, geographic isolation, extinction filtering, climatic change, ecological opportunity and historical contingency as possible factors contributing to relictuality. Importantly, morphological conservatism should not be interpreted as evolutionary inactivity. Fossil evidence demonstrates that Rhynchocephalians, for example, were once morphologically and ecologically diverse, and *Sphenodon* represents only the surviving component of that former adaptive radiation. Similarly, extant crocodilians constitute a small surviving fraction of a much more diverse crocodylomorph evolutionary history. Therefore, the apparent evolutionary conservatism of some living reptiles may partly reflect differential extinction rates and the survival of particular ecological and most adaptive phenotypes rather than an absence of evolutionary change. The term “living fossil” is consequently problematic when it is used to imply evolutionary stagnation. The concept of an evolutionary relicts or phylogenetic relicts provides a more appropriate framework for discussing surviving representatives of ancient and formerly more diverse lineages. Understanding reptilian relicts requires much better integration of evolutionary biology, palaeontology, ecology, biogeography, phylogenetics and finally conservation biology.

Steel, M., Wicke, K. and Mooers, A. (2026). Properties of biodiversity indices that incorporate future extinction risk. [Systematic Biology](#).

Abstract: The loss of biodiversity due to the likely widespread extinction of species in the near future is a focus of current concern in conservation biology. One approach to measure the impact of this extinction is based on the predicted loss of phylogenetic diversity. These predictions have become a focus of the Zoological Society of London's 'EDGE2' program for quantifying biodiversity loss and involves considering the HED (heightened evolutionary distinctiveness) and HEDGE (heightened evolutionary distinctiveness and globally endangered) indices which are based on phylogenetic diversity on a tree. Here, we show how to generalise the HED(GE) indices by expanding their application to more general settings (to phylogenetic networks, to feature diversity on discrete traits, and to arbitrary biodiversity measures). We provide a simple and explicit description of the mean and, importantly, the variance of such measures, and illustrate our results by an application to the phylogeny and a small set of features for all 27 extant crocodilians.

Kamde, L.G., Khedkar, S.S. and Chaudhari, S.S. (2026). Human-wildlife conflict and technological mitigation strategies: a systematic review. [Environmental Science and Pollution Research International](#).

Abstract: The conflict between human and wildlife is called human-

wildlife conflict (HWC). This poses a major obstacle to conservation and to human safety. Following PRISMA 2020 guidelines, this systematic review aimed to explore HWC incidents, contributing factors, mitigation, and technological interventions. The collected information is analyzed for the main categories of conflict, involvement of species, mitigation results, and effectiveness of technological solutions. The results indicated that crop raiding, depredation on livestock, and human attack were the most reported HWC incidents and the most involved species are elephants, tigers, monkeys, and crocodiles. Strong governance, agriculture expansion, habitat fragmentation, and settlement by humans are identified as the major contributors to HWC. The review also confirmed that technological solutions, such as artificial intelligence (AI), deep learning, and machine learning, had positive impacts on the detection, tracking, generation of early warnings, and prediction of conflicts with wildlife. The results of the meta-analysis showed that deep learning techniques had the highest technological effectiveness, 0.83, followed by machine learning (0.76), AI-based systems (0.72), and sensor-based technologies (0.58). The review finds integrated approaches to HWC mitigation using advanced technologies, ecological conservation, and community engagement are the most sustainable ways to minimize HWC and ensure long-term human-wildlife coexistence.

De Freitas, G.I., Rodrigues Jr, C.E., Visciano de Carvalho, D.E., Utsunomia, R. and Porto-Foresti, F. (2026). Hidden biodiversity in wildlife trade networks: DNA barcoding reveals fish and crocodilian Species in commercialized swim bladders. [bioRxiv](#).

Abstract: International wildlife trade represents one of the major drivers of biodiversity exploitation worldwide. However, the true taxonomic diversity embedded within commercial wildlife products often remains unknown because processing removes diagnostic morphological characteristics, preventing reliable species identification. Consequently, biodiversity assessments based solely on product labels may substantially underestimate the diversity of species involved in trade networks. To investigate hidden biodiversity within wildlife trade products, we applied DNA barcoding based on the mitochondrial cytochrome c oxidase subunit I (COI) gene to 77 products commercialized as fish swim bladders and seized at Guarulhos International Airport, Brazil. Molecular analyses successfully identified all samples and revealed the presence of four species: *Plagioscion auratus* (n= 38), *Cynoscion acoupa* (n= 7), *Melanosuchus niger* (n= 17), and *Caiman crocodilus* (n= 15). Fish species accounted for 71.4% of all samples, whereas crocodilians represented 28.6%, demonstrating that products marketed under a single commercial category may conceal substantial taxonomic diversity. Notably, the occurrence of two Amazonian crocodilian species within a trade chain traditionally associated with fish products reveals a previously undocumented component of the international wildlife trade. Our findings demonstrate that DNA barcoding is an effective tool for uncovering hidden biodiversity within processed wildlife products and provide evidence that wildlife trade networks may involve a broader spectrum of species than suggested by commercial labels. These results highlight the importance of molecular surveillance for biodiversity monitoring, wildlife trade regulation, and conservation planning.

Aguiar Vieira, K.R. and Fonseca de Sena, M.B. (2026). Impacto da visitação pública no comportamento e bem-estar do jacaré-tinga em cativeiro. In Anais do V Congresso de Iniciação Científica e Tecnológica, IV Mostra do Stricto Sensu 5(1).

Resumo: O estudo avaliou o perfil comportamental e a ocupação espacial de um jacaré-tinga (*Caiman crocodilus*) no Jardim Zoológico de Brasília, analisando o efeito da visitação pública. A amostragem ocorreu entre janeiro e julho de 2026, somando mais de 44 horas de observação (N= 190 registros etológicos) e mapeamento do recinto. Predominaram o repouso (68,42%) e a termorregulação (16,32%). O espécime permaneceu 54,21% do tempo em imersão

total e 16,32% em imersão parcial. Nos picos de público, a imersão total aumentou 1,67 vez, evidenciando conduta de esquiva. A aplicação de formulário com 100 visitantes indicou que 90,5% desconheciam a espécie e que a inatividade do réptil favorece comportamentos aversivos do público. Recomenda-se a instalação de barreiras visuais, refúgios adicionais e sinalização educativa para mitigar os impactos.

Abstract: This study evaluated the behavioral profile and spatial use of a spectacled caiman (*Caiman crocodilus*) at the Brasília Zoo, analyzing the effect of public visitation. Data collection took place between January and July 2026, totaling over 44 hours of observations (N= 190 ethological records) and enclosure mapping. Resting (68.42%) and thermoregulation (16.32%) were the predominant behaviors. The specimen spent 54.21% of the time fully submerged and 16.32% partially submerged. During peak visitor times, full submersion increased 1.67-fold, indicating avoidance behavior. A survey of 100 visitors revealed that 90.5% were unfamiliar with the species and that the reptile's inactivity fostered aversive behaviors among the public. The installation of visual barriers, additional refuges, and educational signage is recommended to mitigate these impacts.

Willrich, G. and Pilotto, M.R. (2026). Predation of Azara's agouti (*Dasyprocta azarae*) by the broad-snouted caiman (*Caiman latirostris*) in Southern Brazil. *Acta Biológica Catarinense* 13(3): 54-57.

Resumo: O jacaré-de-papo-amarelo (*Caiman latirostris*), um crocodiliano sul-americano amplamente distribuído, habita planícies aluviais, manguezais, lagos e rios, incluindo regiões preservadas e antropogênicas. A espécie é considerada um predador generalista, alimentando-se tanto de invertebrados quanto de vertebrados. Apesar disso, registros de mamíferos na dieta da espécie são particularmente escassos. Portanto, no presente trabalho, é relatada pela primeira vez a predação da cutia (*Dasyprocta azarae*) (Mammalia; Rodentia) por *C. latirostris*. A predação ocorreu no município de Florianópolis, Ilha de Santa Catarina, estado de Santa Catarina, Sul do Brasil. Destaca-se o potencial papel ecológico dos crocodilianos como predadores de roedores de médio porte na América do Sul.

Willrich, G. and Pilotto, M.R. (2026). Predação de cutia (*Dasyprocta azarae*) por jacaré-de-papo-amarelo (*Caiman latirostris*) no Sul do Brasil. *Acta Biológica Catarinense* 13(3): 54-57.

Abstract: The broad-snouted caiman (*Caiman latirostris*) is a widespread South American crocodilian that inhabits floodplains, mangroves, lakes, and rivers, including both wild and anthropogenic regions. The species is considered a generalist predator, feeding on both invertebrates and vertebrates. Despite that, records of mammals on the species' diet are particularly scarce. Therefore, we report here, for the first time, the predation of Azara's agouti (*Dasyprocta azarae*) (Mammalia; Rodentia) by *C. latirostris*. The predation occurred in the municipality of Florianópolis, Santa Catarina Island, Santa Catarina state, Southern Brazil. The present report highlights the ecological role of crocodilians as predators of medium-sized rodents in South America.

Flores, R.J., Eagle, R.A., Trayler, R.B., Larocca Conte, G., Chiarenza, A.A., Farnsworth, A., Valdes, P.J., Chiappe, L. and Tripathi, A. (2026). The body temperature of *Tyrannosaurus rex*. *Science Advances* 12(38).

Abstract: Despite an extensive history of study, quantitative constraints on the thermophysiology of *Tyrannosaurus rex* remain limited. Here, we derive a thermodynamically based determination of *T. rex* body temperatures from clumped isotopes in tooth enamel. Measurements of three *T. rex* teeth from the Late Cretaceous Hell Creek Formation yield a temperature of $36.3 \pm 2.5^\circ\text{C}$ (1

SE), comparable to modern endotherms. Teeth of coeval Hell Creek Formation crocodilians yielded temperatures significantly lower than did those of *T. rex*. Comparison with proxy-derived paleotemperatures and model simulations indicates that *T. rex* maintained a higher body temperature than its environment. Projected habitat suitability for *T. rex* based on these results shows that most of the North American paleocontinent, including colder and higher latitudes, were potentially accessible to the species.

McAllister, C.T. and Arroyo-Torres, I. (2026). Field and laboratory methods for collecting select parasites from amphibians and reptiles. *Journal of Parasitology* 112(5): 565-577

Abstract: A number of publications have reported a variety of methods for processing parasites from many vertebrate clades (eg fishes, birds, and mammals). However, comprehensive reports for parasite screening for amphibians and reptiles (herps) are mostly lacking. Those reports that do exist for herp parasite screening often lack consideration of host and parasite voucher deposition into natural history collections, an incredibly important repository of scientific data. Here, through a review of published literature and compilation of anecdotal experiences, we describe field and laboratory methods for collecting parasites from herps, with special consideration for the deposition of both host and parasite vouchers.

Boerman, S.A.C.M., Burke, P.M.J., Errichon, G., Vellekoop, J., Smith, T., Cossette, A.P., Bourke, J.M., Mannion, P.D. and Martin, J.E. (2026). The endocranial anatomy of 'thoracosaur' crocodyliforms: implications for their ecology and phylogenetic affinities. *Palaeontology* 69(5): e70086.

Abstract: 'Thoracosaurus' are Late Cretaceous to early Palaeogene longirostrine eusuchian crocodyliforms from coastal marine deposits in Europe and North America. Their phylogenetic placement is debated; whereas most morphological studies place them within Gavialidae, implying extensive ghost lineages inconsistent with molecular-based divergence estimates, analyses applying tip-dated Bayesian inference in a total evidence framework retrieve thoracosaurus outside of Crocodylia. Recent advances in computed tomography (CT) scanning of eusuchian skulls have allowed exploration of endocranial anatomy, an additional morphological resource that could contribute to resolving conflicting phylogenetic hypotheses, and shed light on their ecology. Here, we use CT scanning to reconstruct the endocranial cavities of three thoracosaur skulls: *Thoracosaurus isorhynchus* from the Maastrichtian of France and Danian of Sweden, and *Eothoracosaurus mississippiensis* from the Maastrichtian of the USA. Dorsal expansions of the olfactory region within the lacrimals and prefrontals, enlarged semicircular canals of the inner ear, and the absence of a bony wall between the vestibule and the encephalic endocast support a marine ecology for thoracosaurus, consistent with their depositional record and biogeographic distribution. Expansive nasopharyngeal ducts indicate that thoracosaurus were probably incapable of deep diving; instead, they may have used them for acoustic signalling. Comparison of endocranial features of thoracosaurus to extinct and extant crocodyliforms suggests that many of these characteristics are affected by longirostry and/or ecological adaptation. Our results do not clearly support either phylogenetic hypothesis for the position of 'thoracosaurus'. Rather, our study highlights the need for increased taxon sampling to clarify the phylogenetic distribution of endocranial features across Crocodyliformes.

Botha, J., Choiniere, J., Stuart, B. and Weiss, B.M. (2026). Using synchrotron imaging of two new early Jurassic crocodilians to understand locomotion and growth strategies in early crocodile evolution. *European Synchrotron Radiation Facility Data Set*.

Abstract: Modern crocodiles are often seen as sluggish, primitive animals with sprawling postures and aquatic habits remaining

unchanged over millions of years. However, they are derived from small, active protosuchians with erect postures. Understanding the biology of these extremely rare early crocodilians from the early Jurassic is therefore critical for assessing early crocodilian history. We propose to scan two new early South African crocodilians that will assist in our understanding of this group and where the modern traits evolved in the phylogeny. The very gracile specimens preserve elements of the skull, body armour, and extremely long limbs. In this study, we propose to use PPC-SRμCT to image the complete fossil and further at submicron voxel size to image osteohistological cross-sections of the long bones of both fossils. These novel data on the evolution of different growth strategies, locomotion and ecology will help understand the early diversification of crocodilians.

Pritz, M.B. (2026). How crocodiles lost a forebrain circuit. [Neuroscience Letters](#).

Abstract: Why do brain circuits differ among species of the same or different classes of vertebrates? Answers to this question are critical in determining brain organization and evolution. Investigations in mammals and in certain model systems have been the main focus of these studies. Among the areas that have commonly been investigated are cell death, synaptic pruning, and synapse organizing proteins. Whether these same or even other factors sculpt similar circuits in other vertebrates such as reptiles is unknown. The present study examined the development of a well defined circuit in crocodiles and compared it with a similar circuit in mammals. In mammals, cortical areas project directly back to the same dorsal thalamic nucleus that provides its input. However, in reptiles, pallial regions in receipt of dorsal thalamic input do not project directly back to dorsal thalamic nuclei. Instead, pallial areas in reptiles project to the basal nuclei, similar, in part, to the striatum of mammals. The basal nuclei then project back to the dorsal thalamus. This suggested the possibility that this circuit might have been lost in reptiles or perhaps added in mammals. To determine which of these two possibilities might be the case, the development of this circuit in Alligator embryos and juvenile crocodiles was investigated. The results indicate that cell death caused the loss of this circuit in crocodiles and is the likely explanation for this difference. However, a distinction between neuronal death and axonal re-modelling could not be determined.

Arcucci, A., Narváez, I., de Celis, A., Gasca, J.M., de Jesús, S.M., Pinilla-Serrano, I., Catalá, J., Villanueva, A. and Ortega, F. (2026). New cranial remains of *Duerosuchus piscator* (Planocraniidae, Eusuchia) from the Middle Eocene of the Duero Basin (Spain). Boletim de Resumos VIII Congresso Latinoamericano de Paleontologia de Vertebrados. Universidade do Estado do Rio de Janeiro: Rio de Janeiro.

Abstract: The Duero Basin has yielded one of the most diverse Crocodyliformes assemblages known from the European Eocene, including the notosuchian *Iberosuchus* and representatives of Crocodyloidea, Alligatoidea, and Planocraniidae: *Asiatosuchus oenotriensis*, *Diplocynodon tormis*, and *Duerosuchus piscator*. In some cases, it is difficult to delimit the spatial and temporal distribution of each taxon, and there is isolated material of uncertain assignment that is challenging to interpret either as intraspecific variation within known forms or as evidence of a more complex diversity. Among them, *Duerosuchus piscator* was originally described from an incomplete skull, partial lower jaws, several osteoderms, and some vertebrae from the Middle Eocene of Corrales del Vino (Zamora, Spain). A subsequent reevaluation of the cranial material placed *Duerosuchus* as a member of Planocraniidae, a group of ziphodont eusuchian crocodiles from China, Germany and the United States, with no previous confirmed records from the Iberian Peninsula. The members of this group, previously known as “pristichampsines”, are interpreted as having a more terrestrial lifestyle than most other eusuchians. This study describes new cranial remains attributed to *D. piscator* from Corrales del Vino. The specimen preserves the skull table with the postorbital bars, part of

the prefrontals, the exoccipitals, and the quadrates. Comparison with the holotype reveals similar features but also minor differences, such as the morphology of the frontoparietal suture. The new material expands the knowledge of the intraspecific anatomical variability of *D. piscator*, providing a better characterization of the morphology of the taxon within the context of the Duero Basin and improving the understanding of the planocraniid diversity in southwestern Europe.

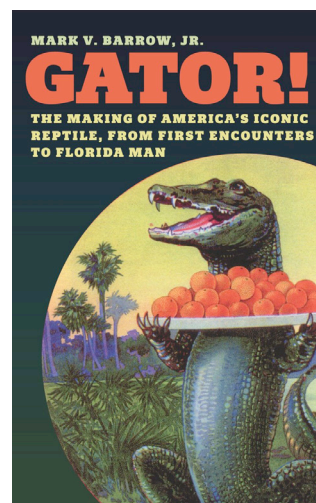
Goodwin, B. (2026). Reptile husbandry: An introduction. General concepts and environment. [Proceedings](#) of New Zealand Veterinary Association & New Zealand Veterinary Nursing Association.

Abstract: Reptiles, encompassing around 12,000 species across four taxonomic orders (Squamata, Chelonina, Crocodilia, and Rhynchocephalia), are wild animals that retain their natural physiology and behaviors even in captivity, requiring a deep understanding of their wild ecology for proper husbandry. Their care involves managing key environmental factors like temperature, humidity, lighting (intensity, color, day length, and UV exposure), and physical space (climbing structures, substrate, water, and enclosure shape) to mimic their natural habitats. Misinterpretations of their survival in suboptimal conditions as “acceptable” can lead to poor welfare, emphasizing the need for informed, science-based practices to ensure their well-being.

Torster, A.H. and Kimble, S.J.A. (2026). Microbial exploration: A review of Sauropsida microbiomes. *Advanced Gut & Microbiome Research* 2026: 1124346.

Abstract: The gut microbiome in Sauropsida - reptiles and wild birds - is vastly understudied. This lack of data and understanding creates an inefficiency in studies and conservation efforts. We address this through a collection of data from 64 published research papers. In this review, we provide a collection of data displaying microbiome variance within Sauropsida, specifically looking at the effects of variables such as captivity status, sex, age, health, and exposure to pollutants. We provide data on commonly used diversity metrics and the geographic bias to universities. The most common dominant microbes across taxa are Proteobacteria, Firmicutes, Bacteroidetes, and Actinobacteria, with variation across the orders. Our results revealed areas that were insufficient in the Sauropsida, displaying a lack of research in biomarkers, Crocodilia, sexes, ages, and results of polluted habitats. The lack of research on these variables serves as a launching point for further research to build further understanding in conservation efforts.

Barrow, M.V. (2026). Gator! The Making of America's Iconic Reptile, from First Encounters to Florida Man. [University of Chicago Press](#).



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