

# **CROCODILE SPECIALIST GROUP NEWSLETTER**

VOLUME 43 No. 2 • APRIL 2024 - JUNE 2024



# CROCODILE

## SPECIALIST

## GROUP

## NEWSLETTER

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APRIL 2024 - JUNE 2024

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IUCN Species Survival Commission

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Cover: Australian Freshwater crocodile (*Crocodylus johnstoni*). Photograph: Yusuke Fukuda.

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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.iucncsg.org/pages/Publications.html>

All CSG communications should be addressed to:  
CSG Executive Office ([csg@wmi.com.au](mailto:csg@wmi.com.au))

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James Hennessy, The National Reptile Zoo, Ireland.  
Cathy Shilton, Darwin, Australia.

## Editorial

The 27th CSG Working Meeting that took place in Darwin, Australia, in April, was considered a resounding success. Sally Isberg, host of the meeting, and her organising committee and dedicated group of volunteers, are to be commended for their efforts in the months leading up to and at the meeting.

With some 300 participants from 30 countries in attendance, the meeting covered a diversity of topics, ranging from farming to toxicology. The last Working Meeting convened in Darwin was in 2004, and so it has been 20 years since Grahame Webb took over as Chair of the CSG. It was thus fitting that recognition of Grahame's 20 years at the CSG's helm, and his longer contribution to CSG and SSC, was celebrated as part of this meeting's program. Although Grahame stepped down from the CSG in late 2023, he continues to contribute to crocodilian conservation, management and research with the passion that he has demonstrated for over 50 years. The traditional auction raised a record amount, which will be used to assist projects in Laos and Ghana. A detailed summary of the Working Meeting is on pages 12-15, and Proceedings are available at: [http://www.iucncsg.org/365\\_docs/attachments/protarea/e29f085e0b48915f4e0d532e14311988.pdf](http://www.iucncsg.org/365_docs/attachments/protarea/e29f085e0b48915f4e0d532e14311988.pdf).

The Working Meeting was preceded by a meeting of the CSG Steering Committee, where a wide range of issues were dealt with. We thank Executive Officer Sally Isberg for pulling together the documentation for what was her first Steering Committee meeting. We were excited to announce that the next Working Meeting will be convened in Morocco in 2026, which will be the first meeting to take place in North Africa. Minutes of the Steering Committee meeting are on pages 4-12.

We also take this opportunity to thank Allan Woodward and Lonnie McCaskill, who stepped down as Regional Chairs for North America and East and Southeast Asia, respectively, for their long service in those positions. We are also thankful that their experience will not be lost to the Steering Committee, as they will continue as members. Thomas Rainwater and Steve Platt have been elevated to the role of Regional Chairs for those regions.

The Executive Committee reported on its decision to establish an Executive Advisory Group (EAG), to sit between the Executive Committee and the Steering Committee, and which it hopes will not only achieve some of the Future Leaders Program's goals, but also act as a group that can work more closely with the EC at a more strategic level. We reiterate that the EAG is not intended to diminish the role of the SC, and it is expected to draw on the relevant skills and expertise from within the SC as well as the broader CSG membership.

Final judgement on the lawsuit involving California and its penal codes as applied to the "importation, possession or sale of the bodies, parts or products of broad-snouted caimans, brown caimans, common caimans, and Yacare caimans" has been issued. *Caiman* has been successfully exempted from the ban enforced by that state. This follows on from the concerted efforts made previously for American alligator (*Alligator mississippiensis*), Nile crocodile (*Crocodylus niloticus*) and Saltwater crocodile (*Crocodylus porosus*).

In late April, the Northern Territory of Australia released its "Saltwater Crocodile Management Program 2024-2034" (<https://becrocwise.nt.gov.au/crocodile-management/crocodile-management-program>). The program allows for targeted removal of crocodiles in specified areas to ensure the safety of swimmers in popular swimming destinations. The 'Be Crocwise' campaign will continue to play an important role in community safety under the new management program. Additional resources will be provided to Aboriginal ranger groups and to the development and deployment of new technologies to improve crocodile detection and monitoring.

The Northern Territory Government also released the "Northern Territory Crocodile Farming Industry Strategic Plan 2024-2033" (<https://industry.nt.gov.au/croc-strategy>). Within the plan, opportunities have been identified to enhance Aboriginal livelihoods and provide working opportunities through active participation in the crocodile industry.

Questions often arise as to the number of extant crocodilian species. The CSG Taxonomy and Identification Working Group has produced a list of the 26 species that are currently recognised by the CSG. The CSG website reflects this list, and details are contained in this Newsletter on pages 15-22. At least two potential species, *Crocodylus halli* and *Osteolaemus afzelii*, are not included at this time, pending further work to confirm species status.

The 10th World Congress of Herpetology (<https://2024wch10.com/>), to be held in Kuching, Sarawak, Malaysia, on 5-9 August 2024, is a major event for herpetologists.

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 one student in the April-June 2024 quarter (see below), and two applications are currently under review.

1. Coralie Galais (France): Effect of moon and nocturnal activity patterns on crocodile detection for abundance estimation in the Yum Balam Natural Protected Area, Mexico.

Dr. Sally Isberg, *CSG Executive Officer* ([csg@wmi.com.au](mailto:csg@wmi.com.au)).

## Minutes of CSG Steering Committee Meeting (Darwin, 15 April 2024)

The CSG Steering Committee meeting was held on 15 April 2024. The meeting began at 0800 h (Darwin time).

Minutes of the meeting are:

### Participants

SC members present in person: Charlie Manolis, Alejandro Larriera, Christine Lippai, Allan Woodward, Alvaro Velasco, Cathy Shilton, Christopher Brochu, Christy Plott, Colette Adams, Curt Harbsmeier, Enrico Chiesa, Eric Langelet, Fabian Schmidt, John Caldwell, Kent Vliet, Lonnie McCaskill, Luis Bassetti, Matthew Brien, Matthew Shirley, Paolo Martelli, Rainier Manalo, Rosanna Mangione, Simone Comparini, Thomas Rainwater, Valentine Lance, Yoichi Takehara, Yusuke Fukuda, Sally Isberg

SC members present by Zoom: Emmanuel Amoah, Pablo Siroski, Marisa Tellez, Gowri Mallapur, Nathalie Kpera, Howard Kelly, Carlos Piña

Observers present in person: Alice Langelet, Ambra Dolfi, Amy Spragge, Annabelle Olsson, Branden Darlison-Hoskin, Charlotte Leyshon, Clare Pearce, Csaba Geczy, Daksh Pandhi, Danie Mulhall, Dave Woods, Deirdre Slawski, Dinouk Perera, Emily Moyes, Erin O'Brien, Garry Lindner, Hallie Cowan, Harada Koki, Irene Chipo Mvere, Jailabdeen Ajji M, James Perran Ross, Juergen Arnold, Katie Sherar, Lauren Lim, Marco Costagli, Maysayanan Thungsen, Noboru Ishii, Pablo Sinovas, Paul Beri, Payton Prosser, Prem Kunwar, Robby McLeod, Savannah Boan, Sebastian Brackhane, Shawn Heflick, Simon Booth, Stefano Pieroni, Steven Leeder, Sukenao Iida, Surathin Wannawatanapong, Somkiat Wannawatanapong, Tim Clancy, Tyson Francis, Mitsuko Takehara, Terry Cullen

SC member apologies: Sen Rith, Xiaobing Wu, Xander Combrink, Hesiquio Benítez

Other apologies: Bruce Shwedick

Agenda: The agenda papers for the Steering Committee (SC) meeting, together with these Minutes, have been posted on the CSG website ([http://www.iucncsg.org/365\\_docs/attachments/protarea/6feabdb7960d8ddfa16c6e6cbffebcfcd.pdf](http://www.iucncsg.org/365_docs/attachments/protarea/6feabdb7960d8ddfa16c6e6cbffebcfcd.pdf)).

## 1. Executive Reports

### 1.1. Chairs' Report

The Chairs opened the meeting by observing a minute's silence for the 14 members/colleagues who have passed since the Chetumal meeting in July 2022, being: Wayne King, Angel Alcalá, James

Aparicio, Juana Peña Flores, Pedro Vasquez Ruesta, Hank Jenkins, Toby Ramos, George Saputra, Tran Van Nga, Goff Letts, Alistair Graham, Luon Nam, Paul Weldon and Chen Bihui.

Alejandro Larriera mentioned that this is the first time that the CSG has been co-chaired, adding that both he and co-Chair Charlie Manolis have been involved in the Executive Committee (EC) for a very long time and have a long institutional memory. Charlie Manolis noted that Grahame Webb stepped down as Chair in October 2023 and, at the same time, Perran Ross stepped down from the CSG; the Chairs expressed their thanks for their efforts over the years and looked forward to continuing to access their extensive institutional knowledge.

The Chairs highlighted the following:

- Bullying, Harassment and Discrimination Policy for CSG-endorsed Events and associated Resolution Procedures documents had been distributed to SC members for their review, and all comments received were assessed and integrated into the versions that are now available on the [CSG website](#).
- The Future Leaders Working Group that was formed in 2014 was morphed into the Future Leaders Program (FLP) in 2018. Whilst the initiative has continued to build the capacity of CSG members (eg sending members to CITES CoPs), the funding required to achieve its goals has not been easy to raise.
- The EC has decided to establish an "Executive Advisory Group" (EAG), to sit between the EC and the SC, and which it hopes will achieve some of the FLP's goals, but also act as a group that can work more closely with the EC at a more strategic level. A tentative list of people has been decided and this will be discussed with those individuals over the coming days. The Chairs stressed that the EAG will not diminish the role of the SC but, as it will address specific issues, the EAG will be expected to draw on the relevant skills and expertise from within the SC as well as the broader CSG membership.
- Changes to the SC are being made where members have asked to step down. Some regions, such as SAI and ESEAsia have country representatives (focal points) on the SC to assist the Regional Chairs. However, other regions (eg WCA, ESAfrica) have very little representation at the country level. Matt Shirley responded that for the WCA, there are difficulties in identifying and retaining people due to issues of funding, programs, etc. This will be discussed throughout the Working Meeting to determine if there is any other way to encourage individual country involvement.
- Terms of Reference for Regional and Thematic Group Chairs will be drafted, to clarify roles and

responsibilities with regard to communication, not only with their members, but also with the EC. Similarly, a revised CSG Membership Nomination Form is being drafted. A few Regional Chairs and Vice-chairs have expressed frustration at the lack of communication or responses to e-mail requests from their regional members. Whilst the IUCN operates on a quadrennium cycle, we appreciate that not all CSG members remain currently active, nor wish to remain active, in the crocodilian space. This revised nomination form will obtain current contact information, particularly for long-term members, but also try to capture an effective membership that is actively contributing in the crocodilian space. These documents will be forthcoming.

Alejandro Larriera clarified the misunderstanding within the CSG membership regarding how the new Chairs were selected. The selection of Grahame Webb in 2004 through an election process within the SC was a one-off situation sought by the CSG and approved by the then SSC Chair. The “normal” process is for the SSC Chair (SSC Executive) to select and appoint Chairs of all specialist groups.

**Action 1:** EO/EC to finalise and distribute: Terms of Reference for Regional and Thematic Group Chairs; and, revised CSG Membership Nomination Form.

## 1.2. Minutes from SC Meeting, Chetumal

Sally Isberg introduced the item. As there were no action items to report against, the report was noted.

## 1.3. Executive Officer Report

Sally Isberg introduced the item.

SI thanked Tom Dacey for his work as the previous Executive Officer (EO), as well as the EC and wider CSG membership for their support since she took over the EO role.

SI confirmed that under the current arrangement, her annual remuneration is \$AUD25,000 which includes all statutory on-costs including superannuation, workers compensation and other insurances, as well as office equipment. A timesheet is maintained and submitted with invoices.

With regard to CSG membership, SI noted that, as of 15 April 2024, there are 732 CSG members from 82 countries listed in the CSG database, comprising a net increase of 22 members and 12 countries since the last SC report. The current SC is composed of 71 members. A Zoom link has been provided to enable those who are not able to attend this meeting in person, and a recording will be distributed at a later date.

SI informed the meeting that she continues to maintain the CSG database, adding that when e-mails are returned as undelivered, efforts are made to contact members via alternate means, generally through the regional chair. However, as instances occur where alternative contact details are not available, SI requested all members to inform the EO whenever member contact details change.

Other highlights in the report include:

- Since the last SC meeting, a review of the “Modelling population dynamics of estuarine crocodiles on Queensland’s northern populated east coast” was conducted and CSG members were attendees at CITES CoP19 held in Panama in November 2022. There have been two successful SSC grants secured, both in 2023, to Marisa Tellez and Matt Shirley. It should be noted that while the CSG is supportive of its members applying for these funds, it is the responsibility of those individuals to fulfill the reporting requirements and the CSG will assume no liability or responsibility for the agreed deliverables. She stressed that CSG members who obtain such grants must be diligent in their acquittal and report to the IUCN/SSC in order that other CSG members are not precluded from applying for further funding rounds.
- the Bullying, Harassment and Discrimination Policy for CSG-endorsed Events and associated Resolution Procedures, as mentioned in the Chairs report. Considerable time and negotiation were required to develop these and ensure alignment with other IUCN policies.
- continuing to develop a communications strategy. The social media team (see 1.3.1 below) has been trialling different ways to increase our engagement of the crocodilian and wider community. The review and redesign of the website is being discussed.
- innovative ways to increase engagement and inclusiveness, as well as deliver the messaging of crocodile conservation and CSG mission. For example, an e-mail list of SRAS recipients will be developed to receive CSG correspondence for the duration of their project. A strategy to create a “interested persons” e-mail list is also underway for people who may not meet the criteria for CSG membership but their interest and involvement in crocodilians may assist us on many levels and is an inclusiveness strategy.
- developing crocodilian conservation priorities.
- The CSG Newsletter is still the primary source of communication.
- The Student Research Assistance Scheme supported 12 projects in 2022, 15 in 2023 and there have been 6 applications so far in 2024. CSG members who are aware of students working with crocodilians are encouraged to let these students know about this scheme so that the CSG

can continue to encourage people working with crocodilians.

The report was noted.

### 1.3.1. Social media

Jen Bruggen gave an update on developments within the social media space, noting the following:

- Most of the social media has been around member awareness, project awareness and increasing the profile of crocodilian conservation. Newsletter items are also now being shared.
- Facebook following is 6.8K and Instagram is 1.8K. The CSG also has LinkedIn and YouTube accounts but needs to better define its goals for the different platforms, which have different reaches for different demographics, etc. For example, do we want to share IUCN best practice guidelines, better awareness of crocodilian conservation issues, etc.

Matt Shirley noted that the CSG's social media strategy should consider integration with other groups such as the International Crocodile Farmers Association (ICFA), People for Wildlife, Louisiana Alligators, etc.

The report was noted.

**Action 2:** EC to ensure Communication Strategy considers: review and re-design of the CSG website; better defined goals for social media platforms; inclusion of SRAS students in CSG communications; and, development of a list of interested people to receive CSG communications.

### 1.4. CSG/IACS Financial Reports

Reports were noted and accepted.

### 1.5. IUCN Membership 2021-2025

The report was accepted and noted.

Charlie Manolis clarified that the nomination process for CSG members ultimately lies with the Chairs, but the preference is that members are nominated through their Regional Chairs and Vice-chairs.

## 2. Regional Reports

### 2.1. East and Southern Africa

Christine Lippai introduced the item, highlighting:

- South Africa:
  - has been developing a biodiversity management plan (BMP) for crocodiles.
  - Non-detriment finding (NDF) has been developed for trade in skins that could impact on the survival of the species in the wild yet there is no wild offtake as the skin industry in South Africa is all closed cycle.
  - genetic admixture is a concern regarding potential reintroduction with facilities housing crocodiles from different drainage basins within the same pens. A study has been initiated to determine this.
  - interest has been expressed for a regional meeting in South Africa and could be integrated with the proposed 28th Working Meeting discussed in item 7.
- Networking within the region continues to be an issue.

Matt Shirley noted that there were parties looking for *Mecistops leptorhynchus* in Zambia. It is unlikely they are present but there are rumours that this is being followed up.

The report was noted.

### 2.2. West and Central Africa

Matt Shirley introduced the item, highlighting:

- Christine Lippai stepped down as Regional Vice-chair and thanked her for her efforts.
- Engagement of regional members has been a major priority along with capacity building. Emmanuel Amoah has a program (THRESCOAL) dedicated to this purpose.
- Red List assessments are progressing slower than desired. A *C. suchus* Red List assessment team has been formed.
- *Osteolaemus* likely has the largest wild meat offtake in the wild and is under no management plan. A SSC Internal Edge grant has been obtained to hold a workshop to develop the Red List and Action Plans for *Osteolaemus*. Taxonomic divisions of *Osteolaemus* are progressing.
- No *Mecistops* were found in a recent reconnaissance trip to Eastern Senegal.

The report was noted.

### 2.3. East and Southeast Asia

Lonnie McCaskill introduced the item, highlighting:

- Laos (*C. siamensis*):
  - World Conservation Society (WCS) headstarting program operates in two villages
  - Tan Soum (10 years) and Dogyanong Villages (recent construction) - and there are



currently 152 crocodiles in the program. 37 were released in March 2024 adding the to previously released 78 individuals from 2022-2023.

- Lao Conservation Trust for Wildlife, previously the Laos Zoo, has identified pure Siamese crocodiles within their stock and the main goal is to support *in-situ* conservation through captive breeding. 10 captive-bred individuals have been donated to the WCS Tan Soum village project for release.
- Cambodia (*C. siamensis*):
  - WCS - since 2021, nests have been found but they have been infertile.
  - Rising Phoenix has released 19 animals since March 2022. In 223, six nests located but none were fertile.
  - Fauna & Flora (FF) has found stable population numbers in the Cardamom Mountains but infertility and embryo death from flooding mean juvenile recruitment is negligible to poor. Ten crocodiles were released in late 2022, totalling 146 in total since 2012 with more planned in the near future.
  - FF work closely with 26 crocodile community wardens that patrol areas in the Cardamom Mountains. Wardens use the SMART patrol system within their sites to monitor, evaluate and respond to threats. Staff have been provided intensive two-day training courses on using the SMART Mobile App for field and photo-based patrol data collection
  - Captive breeding at Phnom Tamao Wildlife Rescue Centre continues producing 60 hatchlings in 2022 and 78 in 2023. DNA analysis is identifying purebred versus hybrid individuals.
  - Surveys within the Virachey National Park have revealed unsuitable habitat for releasing crocodiles.
- Thailand (*C. siamensis*):
  - There have been 3 release programs implemented since 2000 but have had little contribution to the wild stock regarding the number of viable populations. The main obstacles are suitable habitats and multi-agency cooperation. Each government agency (Department of Fisheries and Department of National Parks (DNP)) has its own master plan to manage the habitat and the species. Still, the capability has been built up within these agencies to successfully restock the species in the future.
  - WCS Thailand published a survey report on the status of wild populations in Kaeng Krachan National Park (KKNP) and plans to secure funding for the first reintroduction program soon.
  - A nationwide survey ended in 2020, with an estimated number of wild populations of less

than 100 individuals. No additional surveys were conducted in 2023, except that of KKNP and another in Bueng Borapet Reservoir. Officials and tourists often observed a few guarding mothers and their hatchlings.

- Thai Crocodile Farm Association (TCFA) is actively involved in the ongoing reintroduction and monitoring programs in six protected areas in Thailand, which requires permission.
- Indonesia (*Tomistoma schlegelii*):
  - Masters project in Berbak National Park has defined adult home range size using satellite tracking.
- China (*Alligator sinensis*):
  - Suitable habitats have been expanded and existing habitats have been restored including re-construction of *A. sinensis*' food chain.
  - 1300 of the planned 1500 have been reintroduced with an 80% survival rate one-year post-release. In 2023, 400 eggs were found in 17 nests, with 250 resulting hatchlings.

Rainier Manalo provided the Philippines item, highlighting:

- The Palawan population of *C. porosus* was downlisted to Appendix II, with a zero export quota, at the last CITES CoP.
- Three *C. mindorensis* were repatriated from Cologne Zoo for reintroduction.
- Recent surveys have indicated approximate 300 wild *C. mindorensis*.

Charlie Manolis provided information on Malaysia, highlighting:

- In Sarawak and Sabah, and neighbouring Brunei, human-crocodile conflict (HCC) has increased in frequency, creating anti-crocodile sentiments.
- For states such as Sabah, crocodiles are returning to areas where they have not been seen for decades, and the human population has lost all links to crocodile cohabitation.
- State Governments are looking for removal processes and resolutions with a workshop to be held in Sabah next month.

The reports were noted.

## 2.4. Latin America and the Caribbean

Alejandro Larriera introduced the item, highlighting:

- Commercial programs are declining in Latin America, with the exception of Brazil, and the long-term outcomes of this could be detrimental to crocodile conservation as the livelihood benefits of sustainable use are lost.
- Despite this, there are more people working on research and a representative in Cuba (Gustavo

Sosa Rodriguez) has recently been identified).

Alvaro Velasco delivered a further report on behalf of Pablo Siroski, highlighting:

- Recently, information has been received that some caiman populations in Suriname and Guyana are in drastic decline.
- Student groups are working in Colombia, along with the development of a strong science-based reintroduction program for *Crocodylus intermedius* at the Roberto Franco Station.
- The El Salvador Government has shown interest in hosting an event either in late-2024 or early-2025, with the participation of NGOs and the National University, aimed at fostering collaboration among government representatives, NGOs and universities involved in crocodilian projects across the region.
- Discussions have begun regarding the formation of a working group, or task force, comprising representatives and researchers from countries conducting studies on *Melanosuchus niger*. The goal is to broaden the pool of stakeholders with updated information across the species' distribution range.

The reports were noted.

## 2.5. South Asia and Iran

The report was noted.

## 2.6. Australia and Oceania

Matt Brien introduced the item, highlighting:

- Australia:
  - Review of "Code of Practice on the Humane Treatment of Wild and Farmed Australian Crocodiles" is currently underway.
  - Genetic studies are ongoing in both the Northern Territory (NT) and Queensland (QLD).
  - Both QLD and NT are currently updating their management programs. The NT continues to harvest wild eggs and QLD changed its legislation in 2018 to allow wild harvest and there is currently one operator.
- Palau: small, stable population with HCC rare
- Papua New Guinea: Crocodile Trade Act is being updated to reflect changes within the industry, particularly around licencing, to ensure the conservation and management of the two crocodilian species.
- Timor-Leste: increasing HCC, particularly in the number of fatalities.
- Solomon Islands: country wide surveys in 2019 to develop the national crocodile management plan, although this has not yet been released.

The report was noted.

## 2.7. Europe

Fabian Schmidt introduced the item, highlighting:

- Thomas Ziegler has stepped down as Chair since the last working meeting; Fabian Schmidt and Rosanna Mangione as Regional Chair and Vice-chair, respectively, have added diversity to the European region in terms of both captive and wild crocodilian work.
- Regional collection plan has been developed for crocodiles held in Europe. Little has changed, with the same species included and no change in staffing overseeing these.

Rosanna Mangione highlighted:

- In collaboration with the EO, the membership list has been updated to increase the communication within the region.
- Even though Europe is not a range state for crocodilians, there are many people working in zoos, in welfare as well as in the field in non-European countries.

The reports were noted.

## 2.8. North America

Allan Woodward introduced the item, highlighting:

- *C. acutus* continue to recover with increased nesting and survival. However, HCC issues are increasing with about 200 complaints in Florida each year. The majority are resolved easily but 20-30 require translocation annually.
- *A. mississippiensis* is expanding its range into northern states. Most states have developed a harvest program (commercial and/or hunting).
- Wild harvest skin prices have declined over the last decade placing pressure on the solvency of the businesses that harvest from the wild. The wild harvest contractors also aid in problem alligator removal but with less income from skin sales, the price paid to the contracts has had to increase, placing financial strain on the governmental agencies who administer these.
- Wild egg harvest price has remained quite stable with the quality of the skin determining the viability of the ranching program.

The report was noted.

## 3. Thematic Group Reports

### 3.1. Industry

Christy Plott introduced the item, highlighting:



- Industry and crocodile conservation are intricately linked. However, the overproduction of crocodilian skins, along with a shrinking consumer base, has reduced demand leading to reduced prices.
- Californian law 6530 has been found to be unconstitutional but is still creating some confusion. Caiman lawsuit has also been successful and is now legal for trade again.
- Attacks on industry, even when unsuccessful, have long-standing effects. For example, when Chanel removed its support of reptile skins, this was a household name that had a reputational damage on exotic leathers. Retailers, such as Nordstrom, then followed suit.
- The combination of oversupply and demand reduction has seen prices fall, and it is especially challenging for smaller farms. Measures are underway to try to regain consumer confidence. One example of this is the International Crocodile Farmers Association (ICFA), which was established by farmers to initiate research into science-based welfare items (eg darkness, density) and to ensure traceability and transparency in the supply chain.
- In early 2023, Mexico had a trade ban imposed based on its failure to produce a satisfactory management plan for the Totoaba. Whilst unrelated to crocodilian programs it is an example of how conservation programs can be vulnerable to the impacts from non-related species. Mexico produces a lot of different products, including boots, from *Caiman* species.

A brief discussion was held between the SC participants about how sustainable use is no longer working as a stand-alone story. Consumers want to know more details around the functioning of habitat protection, carbon sequestering, etc.

The report was noted.

### 3.2. Trade Monitoring

John Caldwell introduced the item, highlighting:

- The International Alligator and Crocodile Trade Studies (IACTS) continues to be produced annually and latest report can be found on the CSG website.
- CITES reports from Parties are still lagging for some key countries. If a country fails to produce an annual report for three years, they can face a trade ban.

Alvaro Velasco commented that the CITES report is based on international trade and not necessarily representative of the number of skins traded within countries.

The report was noted.

### 3.3. Veterinary Science

Paolo Martelli thanked the Mexican CSG Working Meeting hosts for holding the veterinary workshop at the last meeting in the absence of the Veterinary Chairs. He informed the meeting that a workshop had been held the day prior to the current SC meeting with wild crocodiles available for necropsy, which allowed real life applications of veterinary science to be discussed.

PM introduced the item, highlighting:

- Communications with members continues to be an issue and perhaps can be resolved through communication with the CSG Executive Officer.
- Still a number of regions without good representation (eg West and Central Africa).

The report was noted.

### 3.4. Zoos

Kent Vliet introduced the item, highlighting:

- Collette Adams was appointed as a Vice-chair of the zoo group since the last meeting.
- Report is focused on American zoos as European zoos were covered within the Europe regional report.
- AZA is moving away from the Species Survival Plans (SSP) programs towards a SAFE model. Earlier this year, the eight crocodilian species listed under SSP have been re-evaluated and six have been reduced to studbook programs. *A. sinensis* and *Tomistoma* are still SSP programs. There is concern because the emphasis is now placed on *ex-situ* conservation (ie just keeping enough diverse genetic stock in zoos) rather than *in situ*. This may create fundraising issues and import permit issues without SSP labels.
- CrocFEST continues to be a great initiative now having raised over \$US900,000 for *in-situ* conservation efforts.
- Croc School continues to be successful after 20 years and over 400 graduates but is now being run by the St Augustine Alligator Farm Croc School.
- Cologne Zoo repatriated three Philippine crocodiles in early 2023.
- Zoos Victoria (Australia) has continued to support the Mabuwaya Foundation's conservation program for *Crocodylus mindorensis*. This is primarily financial, with \$AUD40,000 provided in the 2022-23 financial year and \$AUD30,000 provided in the 2023-24 financial year to date. Advice has also been provided on captive management of Philippine Crocs at the Philippine Crocodile Conservation Centre in San Mariano, Isabella Province in northeast Philippines. Education supplies, which the Foundation

uses for various elements of their community engagement program, benefits wild crocodiles as the more engaged the local people are, the greater the likelihood of them protecting crocodiles and reporting infringements of local and municipal ordinances.

The report was noted.

### 3.5. Taxonomy

Kent Vliet introduced the item, highlighting:

- About 40 people are involved in developing a consensus list of crocodilian taxonomy.
- 26 species, recognising *Osteolaemus osborni*, but not others until final assessments have been published in peer-reviewed literature. This list will be published in the next CSG Newsletter and website. This will be a live document that will be updated as required.
- There has been a large amount of research done on *C. rhombifer*/*C. acutus* hybridisation as well as Caiman throughout their range. There appears to be remarkable population structure within these species.
- While efforts have been placed around anatomy and genetics for speciation, developing tools for customs and trade issues has been a more complex problem.

Discussion items included:

- Chris Brochu noted that sample availability and disproportionate sampling are two major issues when trying to dissociate some of these complexes based on zoo and museum records. For example, there are numerous samples from East Africa but limited specimens from West Africa
- Paolo Martelli proposed to have a laboratory where tissue samples could be submitted to genetically speciate animals. Kent Vliet would like to have both genetic tools as well as dichotomous keys to speciate animals.
- Discussion was held about obtaining further genetic samples from the *C. novaeguineae* distributed within the south of Papua New Guinea to determine if the addition of *C. halli* is appropriate.

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The report was noted.

### 3.6. Legal Affairs

Curt Harbsmeier introduced the item, highlighting:

- CSG members continue to provide advice to governmental agencies as required.
- Australian Department of Climate Change, Energy, the Environment and Water is reviewing

the “Code of Practice on the Humane Treatment of Wild and Farmed Australian Crocodiles”.

- Northern Territory and Queensland crocodile management plans are currently being finalised.
- HCC is increasing (eg Timor-Leste, Jamaica, Cuba, Guatemala). CrocFEST is working with Valerie Garcia (Guatemala) to develop a management plan to help mitigate this and we need to keep working with Governments in all range states.
- South Africa is working on the non-detriment finding for Nile crocodiles and CSG members have been providing evidence and recommendations to the Scientific Authority by the end of the year (as noted in the East & Southern Africa report).
- As reported in the industry-trade report, Californian law 6530 was found to be unconstitutional. The State of California have not contested this ruling which is now final. Christy Plott should be congratulated for her dedication and commitment to this cause and commended on the outcome.
- The Florida Fish and Wildlife Commission approved changes to the current alligator hunt (15 August-1 November; ~7000 permits and ~14,000 alligators) by adding a “special hunt”. This includes issuing another 100 permits (200 alligators) and extending the season to these permit holders until 31 December. These permits will be allocated by a random drawing of applicants in May. Approximately 6000 alligators permitted by the current harvest go unharvested, so the special hunt is not expected to have any measurable impact on the Florida alligator population.

The report was noted.

### 3.7. IUCN Red List Authority

Sally Isberg introduced the item, highlighting:

- Three Red List assessments have been published since the last meeting. These were for *C. rhombifer* (Critically Endangered), *C. moreletii* (Least Concern) and *Tomistoma schlegelii*, which was upgraded from Vulnerable to Endangered. Thank you to all the assessor/authors and the numerous other CSG members who contributed to, or reviewed, these publications.
- The Red List team consists of Sally Isberg, Sergio Balaguera-Reina (GIS), Brandon Sideleau (GIS), Colin Stevenson and Clare Wilkie, with Perran Ross as mentor. Caroline Pollock from the IUCN Red List team also provides support and mentoring as required.
- Processes are now very well-established, using existing Action Plans if they exist as the baseline assessment text. Assessment teams are then assigned by the RLA to update the existing knowledge. Excel and Word-based templates have now been created to assist these assessment

teams and provide support throughout the assessment process. Maps are created using survey data provided and, if none is provided, publicly available information is used, including CrocAttack data. The RLA assessment team then refines this map based on expert knowledge. Once the assessment and RLA teams are happy with the assessment draft, the CSG Chairs provide their review, at which point further experts are often identified, and further items are refined. After these are addressed, the assessments are submitted. A request was made for people to follow this process and not assign their own teams or start their own assessment without conferring with the RLA first.

- There are currently six assessments underway (*C. palustris*, *C. suchus*, *Melanosuchus niger*, *Mecistops cataphractus*, *Mecistops leptorhynchus* and *Osteolaemus*) at various stages.
- The next priorities will be the re-assessment of *C. siamensis* and *C. mindorensis*.
- Indigenous and local knowledge remain a conscious part of all Red List assessments. All assessment teams are encouraged to include references showing communications with locals to empower their voice in the formulation of these assessments.
- Better promoting the publication of Red List assessments is being trialled with a presentation-style YouTube with the assessment team. The first, *Tomistoma* with Kyle Shaney, received good reviews and can be seen as another engagement strategy on the CSG's social media platforms.

The report was noted.

#### 4. Task Force/Working Groups

##### 4.1. Future Leaders Program

Alejandro Larriera introduced the item on behalf of Pablo Siroski, highlighting that the FLP has evolved with many of these members now on the SC and in senior CSG roles. As a result, the FLP model will be dissolved, but activities will continue informally as opportunities arise.

The report was noted.

##### 4.2. Drone Working Group

Lonnie MaCaskill introduced the item, highlighting that while the technology was new, there was a lot of interest and enthusiasm around the working group and workshop, but with the ready integration of this technology into the crocodilian survey, conservation and other needs, it is questioned whether a working group was still appropriate.

Charlie Manolis suggested that the working group

has met its original terms of reference. Discussions should be held to determine the utility of continuing the working group or whether it should be reframed and, if so, in what form.

**Action 3:** Discussions to be held to determine the utility of continuing the Drone Working Group or whether it should be reframed and, if so, in what form.

#### 5. General Business

##### 5.1. CITES (CoP19 and NDF)

Alejandro Larriera introduced the CoP item, highlighting:

- Items from CoP19 (Panama, 2022) have been published in the CSG Newsletter. *C. porosus* (Philippines) and *C. latirostris* (Brazil) were transferred to Appendix II with zero quotas, but the proposal to downlist *C. siamensis* (Thailand) from Appendix I to Appendix II with zero quota was unsuccessful.

Charlie Manolis asked Daniel Natusch to address the item on non-detriment findings (NDFs) and the workshop and NDF guidance recently produced by the CITES Secretariat.

- Dr. Natusch was commissioned by the CITES Secretariat to coordinate the consultants and production of the guidance. This involved 6-months of online meetings to create draft guidance, which then fed into a 160-person workshop in Nairobi in December 2023. At the workshop, finalised guidance was produced that will then be field tested by specific Parties. Working Groups, and hence chapters for which guidance was produced, concerned several thematic and taxon-specific topics. Those related most closely to crocodilians were the generic NDF guidance, the guidance on incorporating the knowledge of Indigenous People and Local Communities into NDF-making, and the guidance on reptiles. For crocodilian NDFs, little has changed with regard to how Parties should undertake NDFs. Dr. Natusch's intervention also touched upon the broader CITES and wildlife trade landscape, especially in relation to Stricter Domestic Measures imposed by some Parties - which, in some cases, relate more to politics and public sentiment (largely driven by Animal Rights NGOs opposed to wildlife trade) than to science. It is anticipated that such measures will become more strict without concerted efforts to reverse this trend.

The reports were noted.



## 5.2. Convention on Migratory Species (CMS)

Charlie Manolis introduced the item, highlighting:

- At CMS CoP14 (Samarkand, Uzbekistan, February 2024), a Resolution was adopted that the CMS Scientific Council would consult with the CSG to determine if crocodilians meet the criteria for CMS inclusion. The definition used by the CMS is “the entire population or any geographically separate part of the population of any species or lower taxon of wild animals, a significant proportion of whose members cyclically and predictably cross one or more national jurisdictional boundaries”. There are currently two crocodilian species listed on the CMS (*Crocodylus porosus* and *Gavialis gangeticus*). As yet, CSG has not been contacted by the CMS.

The report was noted.

## 6. Other Business

- 6.1. Charlie Manolis introduced the item of reinstating the HCC Working Group as proposed by Brandon Sideleau (by e-mail). The original HCC working group was formed in 2002 and had very specific goals that were achieved, and the group was disbanded. If the HCC group were to reform, the goals of the group should be defined and terms of reference developed.

**Action 4:** Discussions to be held to determine the utility of forming a working group, including the development of a draft terms of reference and the outputs to be developed.

- 6.2. Terry Cullen raised concerns around the current membership nomination process and structure of the CSG. Charlie Manolis clarified that the current nomination process through the Regional Chairs and Vice-chairs was working quite well and that the CSG operates on a platform of “tolerance, respect and understanding”.

## 7. 28th CSG Working Meeting

Charlie Manolis informed the SC that two proposals had been received to host the 28th CSG Working Meeting - from Morocco (Crocoparc, Agadir) and Brazil (Caimasul, Corumba). The EC decided that, pending further information, Morocco will host the 28th Working Meeting in 2026. However, as a meeting in Brazil would comprise a different representation of participants, there may be merit in Brazil hosting the 29th Working Meeting in 2027; this would be discussed with the relevant agencies in Brazil.

The meeting closed at 1513 h.

## 27th CSG Working Meeting

The 27th CSG Working Meeting was held in Darwin, Northern Territory, Australia, on 15-19 April 2024. It was attended by 298 delegates and 30 accompanying persons. The Centre for Crocodile Research (Associate Professor Sally Isberg) hosted the meeting, with many sponsors and local businesses providing financial support which significantly offset the cost of the registration fees for participants.

The theme for the Working Meeting was “Crocodile Conservation: What Works!” emphasizing the various aspects that work in unison for crocodile conservation in Australia, and particularly the Northern Territory, to remain the success story it has become.

The Organising Committee (Sally Isberg, Cameron Baker, Cathy Shilton, Charlie Manolis, Emily Moyes, Grahame Webb, Helen Truscott, Kristen Hay, Matt Brien, Mike Welch, Paul Beri, Sam Banks, Simon Booth, Tim Clancy, Yusuke Fukuda) ensured that the venue, program, sponsors, entertainment, etc., were in place. A professional conference organizer, Associated Advertising and Promotions (Kayla Robinson, Helene Bakker, Sita Carolina, Natalie Bell), was contracted to assist with the complex logistic arrangements required to bring delegates from 30 countries (Argentina, Australia, Austria, Bangladesh, Brazil, Cambodia, Czech Republic, Denmark, France, Germany, Ghana, Hong Kong, India, Ireland, Italy, Japan, Malaysia, Mexico, Netherlands, Papua New Guinea, Philippines, Singapore, South Africa, Switzerland, Thailand, United Arab Emirates, United Kingdom, USA, Venezuela, Zimbabwe) to the meeting.

Workshops were held prior to the Working Meeting on 14 April, at Crocodylus Park:

- Drone workshop - coordinated by Matt Brien, Lonnie McCaskill, Simon Booth and Paul Beri (Fig. 1). The workshop featured presentations on best practices, and the use of drones for monitoring, tracking, and management applications.



Figure 1. Matt Brien introducing the day’s agenda for the Drone Workshop.

After some afternoon tea, demonstrations included how to snare crocodiles with drones as a conflict management tool as well as our exhibition sponsor, Wildlife Drones,

showcasing an automated triangulation approach that its drone system can provide. Lunch was sponsored by the North Australian Centre for Autonomous Systems (Dr. Hamish Campbell, Charles Darwin University).

- Veterinary workshop - coordinated by Cathy Shilton, Paolo Martelli and Gowri Mallapur (Fig. 2). The workshop began with presentations on anesthesia, imaging, a case study on limb amputation due to cancer and skin quality defects and diagnosis. After lunch, generously sponsored by Boongarry Veterinary Services (Dr. Annabelle Olsson), some wild crocodile carcasses had been sourced to allow participants to be instructed on necropsy and sample collection techniques. A special thanks to the staff from Berrimah Veterinary Laboratory (Ayril Foster, John Bingham) for volunteering to assist delegates.



Figure 2. Veterinary Science Group co-Chair Dr. Cathy Shilton, demonstrating how to conduct a necropsy on a crocodilian. Photograph: Yusuke Fukuda.

The CSG Steering Committee (SC) meeting was held on 15 April 2024 and was attended by 28 SC members in person and 7 online. There were also 45 observers. CSG Co-Chairs Charlie Manolis and Alejandro Larriera began the SC meeting with 1-minute silence in memory of CSG members and colleagues who had passed away since the previous working meeting in 2022. Finalised Minutes of the SC meeting are on pages 3-12.

The SC meeting was followed by welcome drinks at Crocosaurus Cove, sponsored by Charles Darwin University. Those delegates who registered during the SC meeting went into the draw for a free “Cage of Death” dive at Crocosaurus Cove during the event. Matt Shirley, winner of the draw, donated the prize to Jailabdeen Ajji M and Charmaine Mutswiri, ticking an item off their bucket lists. Also included in the welcome drinks was a smoking ceremony by a member of the local indigenous community, at which attendees were invited to walk through the smoke and be “cleansed”.

The opening of the working meeting on 16 April 2024 began with a Welcome to Country from local Larrakia man, Lucas James. The CSG Co-Chairs then officially opened the meeting before a snapshot of crocodile status within the three Australian States/Territory that have crocodilians

was presented: Ben Corey (Western Australia), Tim Clancy (Northern Territory) and Matt Brien (Queensland). Following this session, to celebrate the legacy of Professor Grahame Webb (previous CSG Chair), a conservation-style interview was held where delegates were treated to an insight into Grahame’s early years and what helped form the strongly resolved personality that has successfully advocated for crocodilians and their conservation for decades. This was interspersed with videos and photographs shared by CSG members with background music chosen from one of the favourite songs of recently departed CSG member, Hank Jenkins.

A presentations session on monitoring and management in Southeast Asia and Oceania was preceded by a session on Australian Crocodile Management opened by Minister Kate Worden, Northern Territory Minister for the Environment, who outlined how important crocodiles are to the Northern Territory, as well as the delicate balance that is required to ensure public safety and tolerance. Other sessions included global crocodilian management, living with crocodilians, technology, general biology, toxicology, veterinary/farming, industry/trade, genetic technologies, taxonomy and systematics, zoos and behaviour.



Figure 3. Rangers from Arafura Swamp Ranger Aboriginal Corporation presented on their work with crocodiles on-country, including the impact of a satellite farm that provides employment and economic opportunities for their remote community. Photograph: Yusuke Fukuda.

Interspersed between the meeting sessions, working groups and thematic groups met [CSG IUCN Red List Authority (Perran Ross, Sally Isberg), Veterinary Science (Paolo Martelli, Cathy Shilton), Industry and Trade (Christy Plott), Taxonomy and Zoos (Kent Vliet).

On the Wednesday night, the Gala Dinner and auction was held at Crocodylus Park. Dr. Ruth Elsey (USA) was chosen as the recipient of the “Castillo Award for Crocodile Conservation” for her more than 40 years of work with American alligators. Ruth was unable to attend the meeting, but she provided a pre-recorded acceptance speech that was played at the auction night. The CSG “Chair’s Encouragement Award” was presented to Yusuke Fukuda (Australia). Both Ruth and Yusuke kindly donated the cash prizes associated with their awards (\$US1000 and \$US500, respectively) back to the CSG, to be used in the CSG’s Student Research Assistance Scheme.



Following the presentations, the inaugural auction was held with auctioneer Shawn Heflick working the crowd to raise funds for crocodilian conservation projects. Assisted by a team of hard-working volunteers, he managed to extricate a record amount of \$US27,897 from participants. Thanks to everyone who donated and participated in this record-breaking event. The funds raised will be divided between:

- Laos Conservation Trust for Wildlife (LCTW), to support captive breeding and reintroduction efforts with the Siamese Crocodile (*Crocodylus siamensis*) in Lao PDR; and,
- a partnership between Threatened Species Conservation Alliance (THRESCOAL, Ghana) and Project Mecistops, where Emmanuel Amoah and Matt Shirley are implementing a conservation science capacity-building program for junior scientists across West Africa.

A cocktail poster session, sponsored by the Crocodilian Academy, was held on the Thursday night to encourage delegates to spend time talking to the authors of the works.

A highlight of the working meeting was a special small feature length presentation by David White from Solar Whisper Daintree Cruises, who showed a series of short videos of crocodile behaviour he has documented over the last 20 years. These were shown just before the closing plenary, captivating the audience.

At the closing session, student prizes were awarded for oral presentations:

- 1st Kaitlin Barham: “Crocodile body temperature and behaviour is affected by long-term changes in climate”.
- 2nd Jailabdeen Ajji M: “Chemo-signalling in Gharial - glandular chemistry of representative wild *Gavialis gangeticus* in the National Chambal Sanctuary, India”.
- 3rd Helen Sung: “Out with the old, introgression with the new hybridization dynamics of *Crocodylus* spp. in Belize”.

And poster presentations:

- 1st Clement S.S. Naabeh: “The vulnerable west African dwarf crocodile is worth conserving in urban ecosystems: evidence from Ghana”
- 2nd Tayhlia Casey, Mariana Campbell, Cameron Baker and Hamish Campbell: “Riparian vegetation vigour correlates with the growth of the Northern Territory estuarine crocodile population”.
- 3rd Sofia Pierini, Melina Simoncini, Alejandro Larriera, Antonio Frutos, Alba Imhof, Florencia Valli, Evangelina Viotto and Carlos Piña: “Not all interactions are negative: Bird assemblages in the Broad-snouted caiman nests”.

After the closing of the meeting, delegates were treated to a private tour of the Museum and Art Gallery of the



Figure 4. Student award winners (from left: Co-Chair Alejandro Larriera, Taylia Casey (2nd poster), Clement Naabeh (1st poster), Helen Sung (3rd oral), Jailabdeen Ajji M (2nd oral), Kaitlin Barham (1st oral), Co-Chair Charlie Manolis). Photograph: Yusuke Fukuda.

Northern Territory and drinks watching the sun going down over Darwin Harbour, before having a banquet meal on the museum lawns. At this event, delegates were treated to Co-Chair Charlie Manolis accompanying local artist Darryl Barba on guitar and backup vocals.

On three mornings during the meeting, the Northern Territory Parks and Wildlife Crocodile Management Team took small groups of people on their routine monitoring routes. Participants were able to witness firsthand the skill and professionalism exhibited by this team as they removed crocodiles from the designated crocodile exclusion zone around Darwin Harbour, which plays a large part in public tolerance of living with an apex predator. Participants were able to talk to the Crocodile Management team members about the techniques, welfare considerations and training that will hopefully be useful in their own local contexts. Huge thanks to Tommy Nichols, Ian Hunt, Kelly Ewin, David Jacobsen, Jaylen Marshall and Kristen Hay for facilitating this unique experience.

The field trip on 20 April involved two concurrent tours. Spectacular Crocodile Cruises was our field trip sponsor, and participants were treated to a river cruise showing this unique and interactive visitor experience that educates hundreds of thousands of visitors to “crocodile country” each year. Participants were also treated to a tour on Corroboree Billabong with our conference partners, Corroboree Billabong Wetland Cruises. On this tour, participants were able to watch both Saltwater and Australian Freshwater crocodiles in the wild along with many birds and other wildlife.

A special mention needs to be made on the group of volunteers who gave up their time to ensure this conference ran smoothly (Michelle Franklin, Eilis Evans, Eva Rettler, Georgia Rankine, Holly Franklin, Jo Leonard, Kade Skelton, Kelly Barker, Saujan Gyawali, Skye Anderson and Tim Palmer). We are so grateful and appreciative of this assistance!

Overall an amazing conference that allowed those present to envisage successful crocodilian conservation into the future.



## Travel Assistance

The meeting website provided an option for participants to donate money for student travel grants through the registration process. This resulted in \$US1100 being raised, and we thank Allan Woodward, Matthew Shirley, Jeff Donald, Ross Dwyer, Robert Godshalk, Shawn Heflick, Paolo Martelli, Christy Plott, Thomas Rainwater, Mitsuko Takehara and Alicia Wassmer for their generous donations. These funds, together with travel funds left over from the Chetumal meeting in 2022, were used to assist Phoebe Griffith and Brinky Desai to attend this meeting. Unfortunately, efforts to bring a participant from Timor Leste to the meeting failed at the last minute.

Sally Isberg, *Host of 27th CSG Working Meeting*.

## **Living Crocodylians of the World (2024)**

The CSG currently recognises 26 species of world crocodilian (Tables 1 and 2), the most recent of which to be recognised being West/Central African species, *Mecistops leptorhynchus* (see Note 1 below), *Osteolaemus osborni* (see *Osteolaemus afzelii* later) and *Crocodylus suchus* (see Note 2 below).

### Caiman crocodilus Group

The exact relationships and boundaries between subspecific units in the *Caiman crocodilus* group remain under study and in need of clarification (eg Amato 1994; Amavet *et al.* 2023; Balaguera *et al.* 2020, 2022; Escobedo-Galván *et al.* 2011, 2015a,b; Medem 1955; Muniz *et al.* 2021; Roberto *et al.* 2020; Venegas-Anaya *et al.* 2008).

Subspecies remain a debated topic within the crocodylian systematics community and at this time the CSG does not recognize valid subspecies. That said, recent molecular comparisons with *Caiman crocodilus apaporiensis* (Balaguera-Reina *et al.* 2020; Roberto *et al.* 2020) suggest that this caiman, despite having some distinct morphology, especially with regard to head shape, is not distinct from *C. c. crocodilus* based on mitochondrial markers. The following subspecies may be relevant species-level units for future consideration:

- Spectacled caiman (*C. c. crocodilus*): South America [Amazon River basin, Orinoco and upper Negro Rivers basins (Amazon lineage), Tapajós, Xingu, plus Araguaia-Tocantins, Parnaíba River basins, coastal drainages in northern South American and northeastern Brazil (Brazilian Shield lineage); Upper Branco River].
- Chiapas caiman (*C. c. chiapasius*): Mexico and northern Central America (southern Mexico and El Salvador drainages).
- Apaporis River caiman (*C. c. apaporiensis*): Colombia (Apaporis River between Jirijirimo and Puerto Yaviya falls).

- Brown caiman (*C. c. fuscus*): Central and South America (Atlantic coast of Costa Rica and probably in Nicaragua and Honduras, Pacific coast of Costa Rica and Panama to trans-Andean Colombia - the Magdalena and Atrato basins, Venezuela - Maracaibo basin and Ecuador).

### Species Yet to be Formally Recognised

Two additional crocodylian “species” have yet to be formally recognised, and have not been included in the CSG’s official list at this time. These are:

- *Crocodylus halli*: The nominate form of *Crocodylus novaeguineae* occupies the northern part of New Guinea and crocodiles in the southern part are reported to differ in morphology and reproduction (Cox 1984; Hall 1985, 1989; Hall and Johnson 197; Hall and Portier 1994; Oaks 2011). There is some preliminary genetic evidence for parphyly in this species. This southern taxon has been named *Crocodylus halli* (Murray *et al.* 2019). The CSG Taxonomy and Identification Group has discussed at length as to whether there is enough support for this newly designated taxon to be included in this current species list. Consensus was that there is insufficient molecular data supporting its inclusion at this time. The group would like more extensive molecular analyses with samples of known provenance.
- *Osteolaemus afzelii* [Benin, Burkina Faso, Côte d’Ivoire, Gambia, Ghana, Guinea, Guinea Bissau, Liberia, Mali, Nigeria(?), Senegal, Sierra Leone, Togo]: Dwarf crocodiles of the genus *Osteolaemus* have long been considered to include two recognized subspecies (*O. t. tetraspis* and *O. t. osborni*). Recent work shows that *Osteolaemus* has significant genetic and some morphological variation meriting species-level recognition of three distinct taxa: *Osteolaemus tetraspis*, *O. osborni*, and an as yet not fully described species (*O. afzelii*) from West Africa (Cope 1861; Eaton *et al.* 2008; Lilljeborg 1867; Schmidt 1919; Shirley *et al.* 2014, 2015).

### Validity in Question

The putative *Crocodylus raninus* is a freshwater crocodile from Borneo (Das and Charles 2000), first proposed as a subspecies of *Crocodylus porosus* (referred to as *C. biporcatus* at the time) by Müller and Schlegel (1844). This taxon is generally synonymized with *C. porosus*, but publications by Ross (1990, 1992) raised renewed awareness of the taxon and stimulated new consideration of its taxonomic validity. Recent efforts to locate living specimens fitting the description of *C. raninus* have been in vain. Efforts are underway to collect DNA from museum specimens of *C. raninus* but are, as yet, unpublished. The CSG Taxonomy and Identification Group refrains from making a determination as to the validity of *C. raninus* at this time.

### Notes

The following notes are provided for a number of species,

Table 1. The 26 species of crocodilian currently recognised by the CSG. \*= IUCN Red List assessment not carried out yet or incomplete. Red List status: LC= Least Concern, VU= Vulnerable, EN= Endangered, CR= Critically Endangered. Other: E= considered extinct, E?= likely extinct, RR (recently rediscovered; Chaudhry *et al.* 2023).

Common Name	Species	Red List	Range States
American Alligator	<i>Alligator mississippiensis</i>	LC	USA
Chinese Alligator	<i>Alligator sinensis</i>	CR	China
Spectacled Caiman	<i>Caiman crocodilus</i>	LC	Costa Rica, El Salvador, Guatemala, Honduras, Brazil, Mexico, Nicaragua, Panama, Colombia, Ecuador, French Guiana, Peru, Guyana, Suriname, Venezuela, Trinidad and Tobago, Bolivia (unconfirmed)
Broad-snouted Caiman	<i>Caiman latirostris</i>	LC	Argentina, Bolivia, Brazil, Paraguay, Uruguay
Yacare Caiman	<i>Caiman yacare</i>	LC	Argentina, Bolivia, Brazil, Paraguay
Black Caiman	<i>Melanosuchus niger</i>	LC	Bolivia, Brazil, Colombia, Ecuador, French Guiana, Guyana, Peru, Venezuela (unconfirmed)
Cuvier's Dwarf Caiman	<i>Paleosuchus palpebrosus</i>	LC	Bolivia, Brazil, Colombia, Ecuador, French Guiana, Guyana, Paraguay, Peru, Suriname, Trinidad and Tobago, Venezuela
Schneider's Smooth-fronted Caiman	<i>Paleosuchus trigonatus</i>	LC	Bolivia, Brazil, Colombia, Ecuador, French Guiana, Peru, Guyana, Suriname, Venezuela
American Crocodile	<i>Crocodylus acutus</i>	VU	Belize, Colombia, Costa Rica, Cuba, Ecuador, Guatemala, Peru, Honduras, Dominican Republic, El Salvador, Haiti, Jamaica, Mexico, Nicaragua, Panama, Venezuela, USA
Orinoco Crocodile	<i>Crocodylus intermedius</i>	CR	Colombia, Venezuela
Australian Freshwater Crocodile	<i>Crocodylus johnstoni</i>	LC	Australia
Philippine Crocodile	<i>Crocodylus mindorensis</i>	CR	Philippines
Morelet's Crocodile	<i>Crocodylus moreletii</i>	LC	Belize, Guatemala, Mexico
Nile Crocodile	<i>Crocodylus niloticus</i>	LC	Angola, Botswana, Burundi, Cameroon, DR Congo, Egypt, Congo, Equatorial Guinea, Eritrea, Eswatini, Ethiopia, Gabon, Kenya, Madagascar, Malawi, Sudan, Mozambique, Namibia, Rwanda, Somalia, Tanzania, South Africa, Uganda, South Sudan, Zambia, Zimbabwe
New Guinea Freshwater Crocodile	<i>Crocodylus novaeguineae</i>	LC	Indonesia, Papua New Guinea
Mugger Crocodile	<i>Crocodylus palustris</i>	VU	India, Iran, Nepal, Pakistan, Sri Lanka
Saltwater Crocodile	<i>Crocodylus porosus</i>	LC	Australia, Bangladesh, Brunei, India, Indonesia, Malaysia, Sri Lanka, Myanmar, Papua New Guinea, Philippines, Singapore, Solomon Islands, Timor-Leste, Vanuatu, Palau, Cambodia(E?), Thailand(E?), Vietnam(E?)
Cuban Crocodile	<i>Crocodylus rhombifer</i>	CR	Cuba
Siamese Crocodile	<i>Crocodylus siamensis</i>	CR	Cambodia, Indonesia, Lao PDR, Thailand, Vietnam. <b>Uncertain:</b> Malaysia, Myanmar
West African Crocodile	<i>Crocodylus suchus</i>	*	Benin, Burkina Faso, Cameroon, Central African Republic, Chad, Guinea, Congo, DR Congo, Côte d'Ivoire, Ethiopia, Gambia, Ghana, Niger, Mali, Guinea-Bissau, Liberia, Mauritania, Nigeria, Senegal, Sierra Leone, Togo, South Sudan, Uganda
West African Slender-snouted Croc.	<i>Mecistops cataphractus</i>	CR	<b>Known:</b> Côte d'Ivoire, Gambia, Ghana, Liberia, Sierra Leone <b>Unknown (possibly Extinct):</b> Benin, Guinea, Burkina Faso, Mali, Togo, Guinea-Bissau, Nigeria, Senegal
Central African Slender-snouted Croc.	<i>Mecistops leptorhynchus</i>	*	<b>Known:</b> Cameroon, Central African Republic, DR Congo, Gabon <b>Unknown (possibly Extinct):</b> Angola, Burundi, Chad, Zambia, Tanzania, Equatorial Guinea, South Sudan
African Dwarf Crocodile	<i>Osteolaemus tetraspis</i>	VU	<b>Known:</b> Angola, Benin, Cameroon, Congo, DR Congo, Gabon, Nigeria, Togo, Côte d'Ivoire, Gambia, Ghana, Guinea-Bissau, Guinea, Liberia, Mali, Sierra Leone. <b>Unknown (possibly Extinct):</b> Burkina Faso, Senegal
Congo Dwarf Crocodile	<i>Osteolaemus osborni</i>	*	<b>Known:</b> Cameroon, Central African Republic, DR Congo, Congo <b>Unknown:</b> Angola
Indian Gharial	<i>Gavialis gangeticus</i>	CR	Bangladesh, India, Nepal, Pakistan (RR)
Tomistoma	<i>Tomistoma schlegelii</i>	EN	Indonesia, Malaysia, Brunei, Thailand (E), Vietnam (E)

and have also been referenced in Table 2.

1. *Caiman latirostris* is part of a species complex based on previous published articles (eg Borges *et al.* 2018; Roberto *et al.* 2020), with three well delimited lineages.
2. Populations of *Paleosuchus palpebrosus* show three distinct haplotype clusters of 22 distinct haplotypes of cytb (Muniz *et al.* 2018, 2021). These authors also analyzed SNP-type nuDNA molecular and detected three distinct evolutionary significant units (Madeira-Bolivia, Amazon and Pantanal). The cytb data supports Madeira and Bolivia as distinct management units. A recent chapter (Muniz *et al.* 2021) updates the distribution of the ESU from Pantanal, that occurs throughout the upper Paraguay River basin, Paraná River, and much of the Brazilian Shield.
3. Analyses of *Paleosuchus trigonatus* populations across the range show clusters of four haplotype groups consisting of 36 unique haplotypes of cytb (Bittencourt *et al.* 2019). Two genetic lineages were recognized - one in the Guiana Shield region (Guyana, French Guiana, Amapá and Upper Branco River in Brazil), and another along the Amazon River and Araguaia-Tocantins basin.
4. Some regional structuring and cryptic species of *Crocodylus acutus* may be present, but this is not yet widely published or conclusive. The thought that Antillean populations might represent divergent species appears to no longer be the prevailing hypothesis, with an historic mitochondrial capture event much more likely (Bashyal *et al.* 2014; Milian-Garcia *et al.* 2011, 2018, 2020; Moncada-Jimenez *et al.* 2023).
5. Originally described as *Crocodylus johnsoni* but commonly referred to as *Crocodylus johnstoni*. The IUCN Red List and CITES use the name *Crocodylus johnstoni* and list *Crocodylus johnsoni* as a synonym. It is clear in Krefft's original 1873 description that the use of the name *johnsoni* was not a typographical error, as he used it repeatedly throughout the paper (Krefft 1873). As such, Article 32d of the International Code of Zoological Nomenclature (ICZN) does not apply in this case. King and Burke (1989), clearly state that the rules of the ICZN dictate that the specific epithet *johnsoni* must stand and could only be corrected by submitting an appeal to the ICZN. However, as pointed out by Tucker (2010), Article 33.2.3.1 of the 4th edition of the ICZN modified the rules relative to emendation of erroneous names of taxa. The new interpretation allows the spelling of *johnstoni* as a justified emendation in stating "when an unjustified emendation is in prevailing usage and is attributed to the original author and date it is deemed to be a justified emendation." Although the CSG Taxonomy and Identification Group consider either form of the specific epithet (*johnsoni* or *johnstoni*) to be of correct usage, *Crocodylus johnstoni* is the name most commonly applied in the scientific and general literature, and in Australian State/Territory and Federal legislation.
6. An extensive, stable and ancient hybrid zone with *Crocodylus moreletii* and *C. acutus* has been described. There is no evidence that this will alter the current specific validity of *C. moreletii* (Barão-Nóbrega *et al.* 2023; Cedeño *et al.* 2008; Hekkala *et al.* 2015; Ray *et al.* 2004).
7. Deraniyagala (1936) described the *Crocodylus palustris* of Sri Lanka (then Ceylon) as a separate subspecies from that of the Indian Mugger. This new subspecies he named *Crocodylus palustris kimbula*. The distinction was largely based on counts of dorsal scale rows, the shape and size of dorsal osteoderms, and the apparent lack of a ventral collar, among other differences. In recent decades, this taxon has been lacking in popular support and is rarely mentioned in the literature. No-one appears to be working on this from a molecular perspective.
8. Extensive hybridization in the wild between *Crocodylus rhombifer* and *C. acutus* has been reported (Milián-García *et al.* 2011, 2015; Pacheco-Sierra *et al.* 2016; see also Note 6). Recent evidence suggests that the formerly re-established population of *C. rhombifer* on Isla de la Juventud has again been wiped out by poaching.
9. The taxon validity of *Crocodylus suchus* is supported by molecular and karyotypic evidence, and it is now widely accepted in the literature (Cunningham *et al.* 2016; Hekkala *et al.* 2011; Shirley *et al.* 2015).
10. Resurrection of the genus *Mecistops* was proposed based on its sister taxon status to *Osteolaemus*, and subsequent work has shown significant molecular and morphological evidence for cryptic species structure with two species, one in West (*M. cataphractus*) and one in Central Africa (*M. leptorhynchus*) (McAliley *et al.* 2006; Shirley *et al.* 2014, 2018). The taxonomy of *M. leptorhynchus* has been published and is gaining acceptance in the literature. We do not advocate the use of "sharp-nosed crocodile" as a common name in a context referring to live animals and recognize this English nomenclature exclusively due to its presence in the paleontological literature.

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Table 2. The 26 species of crocodilian currently recognised by the CSG, with biogeographic distribution.

Common Name	Biogeographic Distribution
American Alligator <i>Alligator mississippiensis</i> (Daudin, 1802)	Southeastern USA (Alabama, Arkansas, Florida, Georgia, Louisiana, Mississippi, Oklahoma, South Carolina, North Carolina, Texas)
Chinese Alligator <i>Alligator sinensis</i> (Fauvel, 1879)	Lower Yangtze River (very limited and fragmented)
Spectacled Caiman <i>Caiman crocodilus</i> (Linnaeus, 1758)	Very widespread from southern Mexico, lower elevations of Central America, northern South America, south to northern Argentina. Found on Trinidad and Tobago, occasional scattered records in the Lesser Antilles. Introduced in Puerto Rico, Cuba, and in extreme southern Florida (USA)
Broad-snouted Caiman <i>Caiman latirostris</i> (Daudin, 1802) See Note 1	Drainages of the Paraná, Paraguay, Uruguay and São Francisco River systems, as well as numerous small Atlantic coast drainages from Natal (northeastern tip of Brazil) to northeast Uruguay
Yacare Caiman <i>Caiman yacare</i> (Daudin, 1802)	Restricted to the river drainages/basins of the Madeira River, and its tributaries (Amazon system) and Parana-Paraguay River system south to Corrientes Province in northern Argentina, including the Pantanal
Black Caiman <i>Melanosuchus niger</i> (Spix, 1825)	Widely distributed throughout the Amazon River basin. Populations also known from Rupununi and upper Essequibo River drainages (Guyana), Kaw and Approuague region (French Guiana), lower Oiapoque River (Amapá, Brazil/French Guiana border), Pointe Behague (French Guiana), and Cabo Orange (Brazil)
Cuvier's Dwarf Caiman <i>Paleosuchus palpebrosus</i> (Cuvier, 1807) See Note 2	Amazon and Orinoco River drainages and Atlantic coast drainages between the Paraguay-Paraná River (except the Pantanal) and the São Francisco River. Small populations in the upper Paraguay River drainage (Paraguay). Also, populations along the Cerrado Domain in Brazil, in the Parnaíba, Tocantins-Araguaia River basins, and coastal drainages in northeastern Brazil.
Schneider's Smooth-fronted Caiman <i>Paleosuchus trigonatus</i> (Schneider, 1801) See Note 3	Amazon and Orinoco basins and coastal drainages in northern South America
American Crocodile <i>Crocodylus acutus</i> (Cuvier, 1807) See Note 4	Greater Antilles, Caribbean and Pacific Coast of Central and northern South America
Orinoco Crocodile <i>Crocodylus intermedius</i> (Graves, 1819)	Restricted to the Orinoco River basin, and today only found in large rivers (eg Arauca, Bitá, Cinaruco, Guaviare, Guayabero, Lozada, Meta, Vichada, Orinoco, Casanare, Cusiana, Ele, Lipa, Cravo Norte, Cravo Sur, Ariporo, Manacacias, Apure, Portuguesa, Tucupido, Cojedes, Manapire, Capanaparo, Ventuari, Caura, Zuata, and some of their tributaries). Occurring historically from the Lozada-Duda-Guayabero River system in central Colombia to the Orinoco delta in northeastern Venezuela. The Paragua and Jao Rivers (Orinoco River tributaries) between San Fernando de Atabapo and La Misión de La Esmeralda were the southernmost distribution. The eastern Andes, Merida Cordilleras in the west, Venezuelan coastal range in the north, and the Guiana shield in the southeast geologically constrained its distribution.
Australian Freshwater Crocodile <i>Crocodylus johnstoni</i> (Kreffft, 1873) See Note 5.	Northern, northeast and northwest wet/dry tropical regions of Western Australia, Northern Territory and Queensland, Australia
Philippine Crocodile <i>Crocodylus mindorensis</i> (Schmidt, 1935)	Contemporarily only on Dalupiri Island, Northern Luzon and Ligawasan marsh on Mindanao. Historically from Luzon, Mindoro, Masbate, Samar, Jolo, Negros, Busuanga and Mindanao. Recently introduced on Siargao Island
Morelet's Crocodile <i>Crocodylus moreletii</i> (Duméril, Bibron & Duméril, 1851) See Note 6	Central American Bioregion. Central Tamaulipas area through the Yucatan Peninsula
Nile Crocodile <i>Crocodylus niloticus</i> (Laurenti, 1768)	Sub-Saharan Africa. Bioregions of East Central Africa, West Central Africa (coastal), Southern Africa, and Madagascar. Southern and East Africa, coastal Central Africa. Historically extended into the Levant of the Eastern Mediterranean

Table 2 cont'd. The 26 species of crocodilian currently recognised by the CSG, with biogeographic distribution.

Common Name	Biogeographic Distribution
New Guinea Freshwater Crocodile <i>Crocodylus novaeguineae</i> (Schmidt, 1928)	Northern Papua New Guinea, southern Papua New Guinea, Papua Province and Pulau Kimaam off the southwestern coast of Papua
Mugger Crocodile <i>Crocodylus palustris</i> (Lesson, 1831) See Note 7	In Tropical Wet, Tropical Wet and Dry, and Humid subtropical bioregions of South Asia. Freshwater, brackish and neritic marine habitats of the South Asian subcontinent, including artificial ponds and water storage structures.
Saltwater Crocodile <i>Crocodylus porosus</i> (Schneider, 1801)	Indo-Pacific widespread. Coastal habitats and tidal rivers from northern Australia, Papua New Guinea, Solomon Islands, Micronesia, Philippine Islands, Indonesia, southeast Asia, Eastern India and Sri Lanka
Cuban Crocodile <i>Crocodylus rhombifer</i> (Cuvier, 1807) See Note 8	Zapata Swamp. Appears to have been recently extirpated from Lanier Swamp (Isla de la Juventud) due to poaching
Siamese Crocodile <i>Crocodylus siamensis</i> (Schneider, 1801)	Historically occurred over much of Southeast Asia lowland, possibly Malay Peninsula, and parts of Sundaland subregions. Current distribution is greatly diminished and fragmented.
West African Crocodile <i>Crocodylus suchus</i> (Geoffroy Saint-Hilaire, 1807) See Note 9	West Africa, Eastern and Western Central Africa remnant populations scattered in North Africa and Sahara Desert. Guinean Forest and Congo Basin biogeographic regions, Sudano-Sahel and patchily throughout the Sahara, Kidepo Valley and Awash drainages in the east
West African Slender-snouted Crocodile <i>Mecistops cataphractus</i> (Cuvier, 1824) See Note 10	Upper Guinea biogeographic zone from the Cross River west to the Gambia River
Central African Slender-snouted Crocodile <i>Mecistops leptorhynchus</i> (Bennett, 1835) See Note 10	Lower Guinean Forest Biome and Congo Basin, from the Gabonese coast and the Sangha-Dja River drainage, north to the Uele River, east to Lake Tanganyika, including the Malagarasi River drainage on the eastern shore, and Lake Mweru and its drainages
African Dwarf Crocodile <i>Osteolaemus tetraspis</i> (Cope, 1861)	Lower Guinea biogeographic zone. Upper Guinea biogeographic.
Congo Dwarf Crocodile <i>Osteolaemus osborni</i> (Schmidt, 1919)	Congo Basin biogeographic zone
Indian Gharial <i>Gavialis gangeticus</i> (Gmelin, 1789)	Now restricted largely to the Indo-Gangetic Plains. Main rivers and tributaries of the Indus, Gangetic and Brahmaputra drainages
Tomistoma <i>Tomistoma schlegelii</i> (Müller, 1838)	Occupying portions of the Malayan Peninsula and Sundaland biogeographic subregions of Southeast Asia, extending over lowland regions of eastern Sumatra, Kalimantan and western Java (Indonesia), and Sarawak and Peninsular Malaysia (Malaysia), within 5° north and south of the equator

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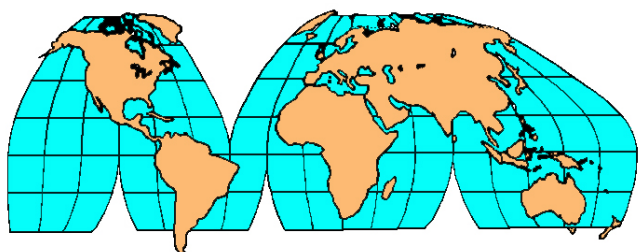
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## Regional Reports



### South Asia and Iran

#### India

INCIDENCE OF CANNIBALISM IN THE POPULATION OF ESTUARINE CROCODILES (*CROCODYLUS POROSUS*) IN THE RIVER SYSTEMS OF BHITARKANIKA NATIONAL PARK, ODISHA, INDIA. Bhitarkanika Wildlife Sanctuary/National Park (BWS/NP) has the distinction of having the largest population of the Estuarine crocodiles (*Crocodylus porosus*) in India (Kar 2024). The initial census on population status in the river systems in and around Bhitarkanika (Fig. 1), conducted in December 1976 and January 1977, indicated that only 96 crocodiles (61 juveniles, 6 sub-adults, 29 adults) (Kar 1980, 1981; Kar and Bustard 1989). With the successful implementation of the FAO/UNDP/GOI/Odisha Forest Department Project “Crocodile Breeding and Management” in Bhitarkanika in mid-1975, the crocodile population has increased significantly, with 1811 sightings in January 2024 (Kar 2024).

Besides annual winter census operations, monitoring of the crocodile population in Bhitarkanika has been a regular feature since 1976 (Kar 1989, 2024). In November 2022, while patrolling the main Bhitarkanika River, the first incidence of cannibalism was recorded. Another case was recorded in the main river, near Mainsamada Creek, in December 2023.

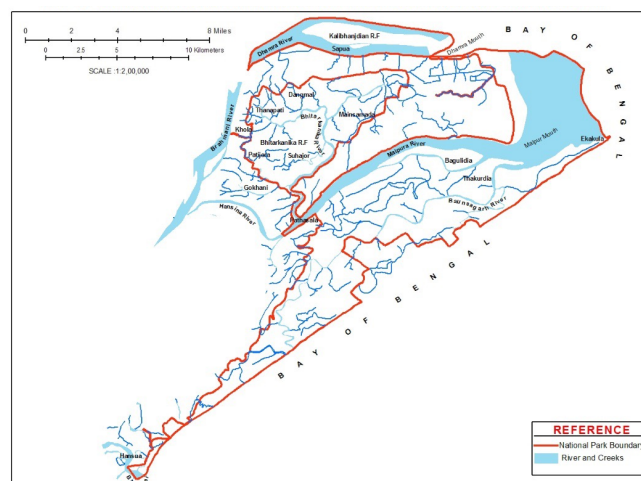


Figure 1. Bhitarkanika National Park, showing major river systems.

Cannibalism was not recorded during study periods over the last 47 years.

Case 1: A large (~5.6 m TL) male Estuarine crocodile was observed grabbing a 1.2 m long partially white juvenile crocodile (locally known as “Sankhua”), which was basking on a bank at the confluence of Suhajora Creek and the main Bhitarkanika River. The male quickly went into water with the juvenile crocodile in its mouth and submerged. After a couple of minutes, it surfaced, by which time the juvenile crocodile appeared to be dead. Seeing the survey team, the male submerged again, and on surfacing attempted to swallow the juvenile. It took some time to swallow the entire body, but it succeeded after repeated attempts.

Case 2: At the lowest tide conditions of the Bhitarkanika River, in the cool December 2023 noon hours, a basking adult female Estuarine crocodile (3.5 m TL) was observed catching a basking sub-adult crocodile (1.5 m TL) around its neck (Fig. 2). The juvenile crocodile struggled to escape the grip of the larger female, but was not successful. Suddenly, the female slipped into the water and submerged (Fig. 2). After a couple of minutes, the female surfaced with the dead juvenile, swam into mid-river, and submerged again. She was sighted on the opposite bank for a longer period, but feeding on the dead juvenile was not observed due to distance/time limitations on the survey team.

The Bhitarkanika mangrove ecosystem is considered to contain sufficient prey (fish, shrimps, etc.) for all age/size classes of crocodiles, including 348 adults (see Kar 2024). The increasing frequency of reproduction (nesting), also supports this, with nesting increasing from 5 nests in 1976 to 122 nests in 2023. Crocodiles sighted during annual surveys in Bhitarkanika appear healthy and in good condition.

Over 47 years of study, with both night and day surveys, these are the only two cases of cannibalism that have been observed. Surveys are carried out in the winter months, when crocodiles are basking for long periods to increase body temperature, and considered to have a lower appetite.



Figure 2. (Top) Adult female Estuarine crocodile (~3.4 m TL) catching a sub-adult crocodile by the neck on the Bhitarkanika River: and, (Bottom) suddenly jumping into the water with it. Photographs: Mangrove Wildlife Division, Rajnagar.

It has been observed that small and large crocodiles in Bhitarkanika invariably maintain some distance between them. In both of these cases, the juvenile and sub-adult crocodiles were very close to the adults as they basked, which was unusual. Although the adults were observed to eventually feed on the smaller conspecifics, the reason for the initial “attack” may have been prompted by territoriality.

Cannibalism has been reported in various species of crocodilian (eg Pooley 1969; Rootes and Chabreck 1993; Delany *et al.* 2011), and is considered to apply generally across species. Shantanu *et al.* (2023) reported on cannibalism by an adult *C. palustris* on a sub-adult Mugger in the Girwa River of Katarniaghat Wildlife Sanctuary, and stated “cannibalism can be attributed to stress related to resources, competition, and sometimes, just easy access to another member of the same species”. However, Grigg and Kirshner (2015) highlighted that the importance of cannibalism as a regulatory mechanism remains unclear. Cott (1961) and Webb and Manolis (1998) observed that larger individuals are major predators of smaller ones both within and between species.

In the case of Bhitarkanika, the *C. porosus* population has been biased towards a high proportion large individuals in recent years. Webb and Manolis (1992) demonstrated clear

density-dependent factors in the recovering population of *C. porosus* in the Northern Territory of Australia, with numbers of small crocodiles being significantly related to the numbers of large crocodiles. Whether such factors are operating in Bhitarkanika, with the changing abundance and size structure of *C. porosus* there, remains to be confirmed.

#### Acknowledgements

I am thankful to the Chief Wildlife Wardens, Odisha and Wildlife Wardens of Athagarh Forest Division, as well as Wildlife Wardens of the Bhitarkanika Mangrove (Wildlife) Division, Chandabali/Rajnagar for extending support to conduct the study on ecology and biology of Estuarine crocodiles in Bhitarkanika Wildlife Sanctuary/National Park since July 1975. My special thanks to the river patrolling staff of the Mangrove Wildlife Division, Rajnagar for their dedicated activities and field observations.

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**TURNING THE TABLES: PREDATOR-PREY RELATIONSHIPS.** Role reversal in predator-prey relationships is a rare phenomenon, even though the latter has been well studied. There are reviewed cases of prey confronting the potential predator (Magalhaes *et al.* 2005), however, role reversal in predator-prey interactions has been explored less. Here, I present noteworthy incidents in prey-predator relationships involving the Mugger (*Crocodylus palustris*).

A recently published literature survey showed 19 species of bird from 12 families (Anatidae, Ardeidae, Rallidae, Phasianidae, Columbidae, Accipitridae, Podicipedidae, Phalacrocoracidae, Ciconiidae, Charadriidae, Recurvirostridae, Strigidae) in the diet of Muggers (Hakim and Sharma 2024). Hakim and Sharma (2024) also reported for the first time on a specific observation in March 2023 from the Girwa River in Bardiya National Park, Nepal, of Mugger predation on a Brown Fish Owl (*Ketupa zeylonensis*).

The Brown Fish Owl is a nocturnal species known for its adaptability, usually feeding on fish and other aquatic invertebrates and vertebrates (Grimmett *et al.* 1998). Breeding pairs of owls are often found foraging in similar spots (Vyas *et al.* 2013), and such foraging habits may increase their vulnerability to predation by wetland predators like Muggers. A recent Facebook post by Singh (2024) further highlights the adaptability of these owls, showing an observation from 6 May 2024 at Ranthambore National Park, Rajasthan, India, of a Brown Fish Owl predating a Mugger hatchling.

These unique events, where the predator becomes the prey, are intriguing to note. These events align with both species' breeding seasons, as Holt *et al.* (2020) reported the breeding season of the Brown Fish Owl is November-May, and Mugger nesting occurs in February-April, with hatchlings emerging in May-June (Whitaker and Whitaker 1984; Mobaraki *et al.* 2013), although it varies between geographic regions. Muggers and Brown Fish Owls are both master apex

predators in their ecosystems (Vyas 2021; Dias and Borker 2023) and depend on very similar wetland habitats, but each other's tolerance depends on size and situation proximity.

A similar prey and predator relationship was also noted with wader bird species, with Painted Stork (*Mycteria leucocephala*) predation by Mugger at Ranganthittu Bird Sanctuary, Karnataka, India (Vengopal 2006) and Painted Stork predation on a hatchling Mugger at Yala National Park, Sri Lanka (see Somaweera *et al.* 2013).

Similar prey-predator relationships in the literature turn the tables with two large felines:

- Laydekker (1884) mentioned (with evidence illustration) an attack by a large Mugger on a Bengal tiger (*Panthera tigris*). A female tiger named 'machhli' (= fish) from Ranthambore Tiger Reserve, Rajasthan, India, was famous for preying on Muggers (Somaweera *et al.* 2013; Vyas 2021).
- An Asiatic Lion (*Panthera leo persica*) devoured a sub-adult Mugger at Gir Wildlife Sanctuary and National Park (Vyas 2008; Somaweera *et al.* 2013). There were two incidents where lions were victimized by a few Muggers; the first in September 2014 involving an adult lion at Mandhuvanti Dam, west Gir (Vyas 2020), and the second in May 2016 involving a sub-adult lion at Khodiar Ghuna, Hadala, Gir forest (Vyas 2021).

All these cases involved predators whose predation upon another organism was governed by parameters such as relative size or abundance.

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HABITAT SUITABILITY ASSESSMENT FOR GHARIAL (*GAVALIS GANGETICUS*) ALONG THE BRAHMAPUTRA RIVER IN ASSAM, INDIA. The Gharial (*Gavialis gangeticus*) (Gmelin, 1789) is a critically endangered, river-dwelling crocodilian endemic to the Indian sub-continent, with very few breeding adults remaining (Lang *et al.* 2019). India's largest Gharial population resides in the National Chambal Sanctuary, which hosts approximately

77% of the global adult population, and the remaining Gharial populations in India are scattered over various locations, including Katarniaghat Wildlife Sanctuary (Uttar Pradesh), Corbett National Park, Hastinapur Sanctuary, the Gandak, Son, Ken, Ghaghara, Mahanadi and Yamuna Rivers, and the Brahmaputra drainage in northeast India (Lang *et al.* 2019).

Gharials were believed to be abundant in the Brahmaputra River, however the possibility of existing breeding population is negligible (Choudhury 1997). There used to be a significant population in Chandubi tectonic lake prior to 1973 owing to the close proximity to the Brahmaputra River (Saikia *et al.* 2010). Potential sightings along the Brahmaputra's main channel were recorded during surveys spanning 1979 to 1993, including landscapes of Kaziranga National Park, Dibru-Saikhowa Biosphere Reserve and Orang Tiger Reserve (Choudhury 1997). Whereas, intermittent populations were recorded from Urpod Beel, Dikhow River, Dibru-Saikhowa Biosphere Reserve and majorly Brahmaputra-Jinjiram-Ghagar-Subansiri-Manas-Beki River systems during another survey from 2004 to 2007 (Saikia *et al.* 2010). However, no Gharial were recorded in a dedicated survey in Manas, Nameri, Orang, Kaziranga, Dibru-Saikhowa National Park and D'Ering Sanctuary (Das *et al.* 2011).

A 160-km survey of the Brahmaputra River was conducted on 16-25 January 2024 by TSA Foundation India and Assam Forest Department, extending from Kaliabhomora bridge (Sonitpur District; 26° 36'53.09"N, 92° 53'53.49"E) in the west to Komolabari ghat (Majuli District; 26°54'54.50"N, 94° 09'10.39"E) in the east, where elevation varied between 78 and 105 m asl. A team of five members, with two observers, used a single cylinder, double engine boat and a small hand-oared country boat to systematically explore the stretch of river.

The survey was completed in two transects (upstream and downstream) considering the huge width of the river and covering a total of 320 km of shoreline. For documentation of species occurrence, visual encounter surveys through point count (Castello *et al.* 2009) and boat-based transect methods was done. The entire stretch was deconstructed into 2 km segments and each segment was further divided into two zones; 500 m of intensive survey zone and 1.5 km for opportunistic observations (Galan 2015). Average boat speed was 10 km/h, and a maximum of 25-30 km was covered in a single day (Singh *et al.* 2021; Basumatary and Sharma 2013). The team conducted habitat suitability assessments for aquatic reptiles using parameters such as river depth, channel width, channel morphology, vegetation cover and extent, and quality of basking and nesting (soil). Top five habitats were characterised as a result of this survey.

The study area of the river was dominated by sandy shoreline (32%) and shoreline with vegetation cover (30%), followed by muddy shoreline (30%). The depth in the longitudinal survey path of the Brahmaputra River varied from 1.2 m to 12.2 m, with an average depth of 5.2 m. One quarter of the surveyed stretch has complete protection from anthropogenic threats as it falls under Kaziranga National Park and Tiger

Reserve. Among other disturbances, the prominent ones were disturbances from solid wastes from riparian communities (23%) and fishing (20%), followed by livestock grazing (18%) and agriculture (14%).



Figure 1. Potential Gharial habitat.

The survey recorded one adult female Gharial of body length more than 250 cm, towards the western range of Biswanath Wildlife Division, Kaziranga Tiger Reserve. The project team has been monitoring the Brahmaputra stretch since 2021, and conducted 4 consecutive surveys during winters (December-February). The survey team observed a Gharial for the first time in late 2021, however it could not be photographed. Another observation by Kaziranga Tiger Reserve staff and WWF-India recorded a Gharial in the Biswanath Wildlife Division in 2022.

In the present survey, we assume that the same Gharial individual was recorded during two instances on a sandy shoreline, with gentle (<30°) slope. The first instance recorded the Gharial basking on a sand bank with a shoreline water depth of 4.5 m (Fig. 2). The second location was on a shoreline about 500 m away from the former, where the average cross-sectional depth of the river channel was 7.6 m. Both locations were on the same side of the river, but on different days, suggesting a stability in their movement range and tendency of reoccurring at their preferable spots. This could be explained by the habit of Gharials returning to the same basking site every day, which makes them predictable and increases the risk of capture (Whitaker and Basu 1983).



Figure 2. Female Gharial observed during survey. Photograph: Aditya Prasad.

The survey found that potential habitat for Gharials within the recorded locality covers a distance of approximately 10 km, and the depth of the longitudinal path ranges from 1.5-

9.1 m (5.6 m average). The area is characterized by sandy shoreline and sand bars with low to moderate slope. There are no disturbances in this entire stretch as it falls under Kaziranga Tiger Reserve, which enjoys a maximum level of protection.

Further, a Gharial skull (length= 85 cm, width= 35 cm, snout length= 53 cm) housed at the Museum of Zoology Department, Debraj Roy College, Golaghat, was reportedly hunted by a local in the 1980s from the Brahmaputra's main channel (R. Basumatary, pers. comm., 2022). This is arguably a record size for any known Gharial skull from the region. Reported hunting location is about 90 km from the location where we observed the female Gharial.

In summary, this section of the river may be prioritized for detailed surveys and conservation interventions such as future supplementation initiatives along with continuous monitoring exercises over the years to know the actual population status of crocodilians in the Brahmaputra landscape.

#### Acknowledgements

We thank Assam Forest Department, especially Mr. Sandeep Kumar, IFS, Chief Wildlife Warden & PCCF (Wildlife) and Dr. Sonali Ghosh, Director, Kaziranga National Park and Tiger Reserve for guidance and logistic support to carry out the work. We also thank Mr. Tarun Nair from Wildlife Conservation Trust for his valuable inputs in survey design. We acknowledge Dr. Rajeev Basumatary, Debraj Roy College, Golaghat, for providing necessary information.

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## Nepal

RESTORING RIVER BANKS FOR GHARIAL (*GAVALIS GANGETICUS*) CONSERVATION IN CHITWAN NATIONAL PARK, NEPAL. The Gharial (*Gavialis gangeticus*) is a critically endangered species of crocodylian characterized by its long snout and sharp teeth adapted for catching their primary prey - fish (Fig. 1).



Figure 1. Gharials have long and slender snout with needle-like teeth specialized to catch their primary prey - fish. Photograph: Ashish Bashyal.

Two populations of Gharial occur in Nepal, the largest of which is in the interconnected Rapti and Narayani Rivers in Chitwan National Park (CNP) (Lang *et al.* 2021). The Gharial population has greatly recovered in CNP, from as few

as 39 individuals in 2005 to at least 265 in 2024 (Khadka *et al.* 2024). These recoveries are primarily attributable to an extensive rear and release program, with recaptures indicating that the majority of Gharial in the CNP population were given a 'headstart' through this program (Khadka *et al.* 2022).

The Rapti and Narayani Rivers in and around CNP provide critical Gharial habitat (Khadka *et al.* 2020). A recent study suggests that although the CNP Gharial population is increasing, the threats to their survival, such as substrate extraction, illegal fishing and habitat modification, continue to persist (Khadka *et al.* 2024). With an increasing human population across the buffer zone of CNP (henceforth 'the buffer zone'), anthropogenic pressure is also increasing in the riverine system.

There has been significant increase in the human population and presence and size of settlements by the bank of the Rapti and the Narayani Rivers in the buffer zone. Gabion walls have been built in several places to protect against river bank erosion, and reduce risk of flooding of settlements (Fig. 2). It has been observed that fish use the underwater part of the gabion wall extensively as a shelter and breeding grounds, although this was not an intention of the gabion construction. Fish species found in the Rapti and Narayani Rivers, such as Rohu (*Labeo rohita*), Mahasheer (*Tor putitora*), Thend or Gujudi (*Labeo angra*) and Tengri (*Mystus* sp.), use these gabion walls extensively. Fishermen have informed researchers that it is not easy to catch fish hiding underneath or inside the gabion wall when using nets, and they have to patiently wait until fish occasionally come out of the gabion (B. Khadka, pers. comm.). Even fish species that migrate to and from the Ganges are believed to use such gabion walls. During our Gharial surveys (Khadka *et al.* 2020), we have also repeatedly observed Gharials lurking around areas where gabion walls have been built, and have presumed they are following the fishes that make up the majority of their diet.

With the increase in human settlements, there is now a need for constructing more gabion walls to protect both river banks and communities living by the river. While construction of gabion walls is important to protect river banks from unpredictable erosion and its impact on people, and to prevent floodwaters from entering human settlements, such construction will also have environmental impacts. Generally, stones for building gabions are extracted from the river, and trees and vegetation flanking the rivers are cleared to make way for such construction. However, these infrastructure developments along the river banks could also be utilized to restore river bank habitat. If constructed with consideration of biodiversity and environmental restoration, this could have a multitude of benefits for ecologically and socio-culturally important freshwater species (eg fishes, turtles, Gharial, Muggers, smooth-coated otters), as well as to the rivers and humans, including traditional fishing communities. Various bioengineering techniques combined with indigenous traditional knowledge can be used to restore and protect river bank habitat.

Khanyu or drooping fig (*Ficus semicordata*) is an indigenous





Figure 2. Newly constructed gabion wall along bank of the Rapti River in CNP. Photograph: Bed Khadka.

tree species which can be very useful in such efforts, as it does not grow very tall, has a slightly inclined trunk and widely spread out branches, and therefore this species provides shade to underwater microhabitats on the riverbank, helping in maintaining specific temperature microclimates in different seasons. Additionally, other species such as bamboos, wild bananas, amriso (broom plant, *Thysanolaena maxima*), Malabar Nut (*Justicia adhatoda*), narkat (giant reed, *Arundo donax*) are also useful for planting along the gabion wall. Gabion walls flanked by a tree line consisting of these indigenous trees can also act as a barrier, preventing movement of large herbivores such as elephants and rhinos towards human settlements. These large herbivores contribute considerably to human-wildlife conflict in Chitwan (Silwal *et al.* 2017; Dangol *et al.* 2020), and interventions to prevent conflict in the buffer zone should be a priority (Lamicchane *et al.* 2019).

Trees along the gabion wall could be utilized by various species of birds for building nests, and also as a vantage point for piscivorous birds to catch fishes. As mentioned above, the underwater structure of gabion walls can provide hideouts, shelter and breeding grounds for native fish species, including resident and migratory species. We have observed several instances where gabion walls have been beneficial. For example, a gabion wall was constructed near Durbar in Kasara to protect the bank of the Rapti River from erosion (Fig. 3). Over time, native species of trees grew by the gabion and we have observed higher abundance of fishes by the gabion wall. Gharial, and even Muggers, are often found lingering in that area.



Figure 3. Gabion wall flanked by vegetation along bank of the Rapti River in CNP. Photograph: Bed Khadka.

The fate of both the Gharial and the indigenous fishing communities are tied to the fish. In order to promote the co-existence of Gharial and traditional fishing communities, the Chitwan National Park has distributed controlled fishing license to traditional fishing communities that have relied on fishing for generations (Fig. 4; Pathak *et al.* 2023). Based on our informal interviews with some members of such fishing communities, it appears that they used to catch 2.5-3 kg of fish on average in 2003 and now catch around 10-15 kg of fish per day (Bed Khadka, pers. comm.). They agree that fish abundance has increased over the years along with the rise in Gharial numbers. The use of traditional fish nets and fishing techniques along with their generally positive attitude towards gharials indicate a perception that Gharials are important for maintaining high fish abundance.



Figure 4. Traditional fishing communities are provided with fishing licenses, for use of traditional wooden canoes and hand-held nets for fishing. Photograph: Ashish Bashyal.

If forest patches are restored along gabion walls, such patches could be handed over to traditional fishing communities and other local communities for management, following the Nepalese model of community forest management. Community forests have been a huge success in Nepal, due to a system where local communities manage forest patches in the area surrounding their residences, and reap a variety of benefits including the collection of natural resources such as wood and fodder, as well as income generation, such as by conducting nature-based tourism activities such as jungle walks and jeep safaris.

Construction of gabion walls flanked by forest patches, as we have outlined above, could be beneficial to fishes by providing them shelter, breeding grounds and various microclimates through shading, which in turn would be beneficial to Gharials and to indigenous fishing communities. Gharials will have high prey richness, and in turn perform their role as an apex predator in the system, helping maintain healthy stocks of fishes through top-down processes (He *et al.* 2024). An improved harvest of fishes for indigenous fishing communities will also help in providing these communities with a sustainable income. Importantly, having plenty of fishes for harvest is expected to build a more positive attitude of fishing communities towards Gharials, thus minimizing conflicts and promoting co-existence.

We believe that restoring river banks by planting native tree species after the construction of gabion walls, and handing ownership of these forest patches to the local communities, would result in a win-win situation for both people and nature. We recommend that the CNP Buffer Zone Management Committee and all relevant stakeholders consider to restore river banks by planting native species of tree along both current and planned gabion walls.

#### Acknowledgements

We thank Dr. Phoebe Griffith for reviewing and editing this manuscript.

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Silwal, T., Kolejka, J., Bhatta, B.P., Rayamajhi, S., Sharma, R.P. and Poudel, B.S. (2017). When, where and whom: assessing wildlife attacks on people in Chitwan National Park, Nepal. *Oryx* 51(2): 370-377.

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#### Recent Publications

Hewitt, L., Niemeyer, D. and Small, A. (2024). The use of a penetrative captive bolt device during the killing of farmed saltwater crocodiles (*Crocodylus porosus*). *Journal of Applied Animal Welfare Science* (<https://doi.org/10.1080/10888705.2024.2357580>).

**Abstract:** Killing of farmed saltwater crocodiles involve stunning with a penetrative captive bolt device, followed by a cut across the nape of the neck and physical destruction of the brain to ensure death. This study was a welfare-based assessment of the use of a penetrative captive bolt device in saltwater crocodiles, to determine whether it satisfies the criteria of a humane stunning method and can be regarded as a direct killing method without the need for the application of an adjunct method. Methods used were electroencephalogram (EEG), observation of post-stun behavior, and postmortem examination of gross pathology of the cranium and



brain. 30 of 30 animals, demonstrated immediate and irreversible loss of consciousness. There was extensive damage to the brain in all animals, deemed to be inconsistent with cortical function and possible recovery. The CASH Special 0.22 penetrative captive bolt pistol (1.25 grain cartridge), applied to the top of the cranial plate, produced immediate and irreversible unconsciousness in all the animals studied. This method satisfies animal welfare expectations, providing crocodile processors with a technique that contributes to a humane killing process.

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Campbell, D.L., Hewitt, L., Lee, C., Timmerhues, C.A. and Small, A. (2024). Behaviours of farmed saltwater crocodiles (*Crocodylus porosus*) housed individually or in groups. *Frontiers in Veterinary Science* 11 (doi: [10.3389/fvets.2024.1394198](https://doi.org/10.3389/fvets.2024.1394198)).

**Abstract:** Saltwater crocodiles (*Crocodylus porosus*) are farmed in Australia primarily for their skins and meat. Commercially, they are raised in group pens as hatchlings and grower crocodiles, then moved to unitised (individual) pens for the final finishing stage when they are several years old. They will exhibit aggressive behaviour toward each other in captivity. Unitised pens can prevent animal injury and teeth marks on the skins but may result in other social restrictions. Research into behavioural housing preferences could assist the industry and inform the process of guideline development for optimal crocodile management and welfare. This study assessed the impacts of two housing systems, unitised or group pens, in 20 commercial finishing crocodiles through measuring behavioural profiles of individuals from video recordings, including housing preference when given a choice. Both pens included water and an above-water shelf, but the crocodiles in unitised pens could also access underneath the shelf. A threat perception test was applied to assess anxiety when housed individually or in groups. However, it was difficult to apply a standardised stimulus to all animals that reliably elicited a behavioral response. Further work would be needed to validate this test for commercial reptiles as the outcomes were not robust. The behavioural observation results showed clear differences in where the crocodiles spent their time across the day and in their activity levels between the pen types. However, interpretation of this variation was confounded by the physical as well as social differences between the pen types given the inconsistency in shelf access. Behaviours exhibited also differed given there were social opportunities in the group pens where individuals were observed engaged in both aggressive and non-aggressive contact interactions. In the free choice environment, crocodiles spent similar amounts of time in both unitised and group pens, suggesting there were features of both pen types that were attractive to the animals. However, skins were damaged from teeth marks highlighting the physical as well as economical risks of group housing. Further work could validate behavioural tests to quantify affective state impacts in different housing environments and whether social interactions do provide benefits for improving crocodile welfare.

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Castillo-Rodríguez, M.A., Rangel-Mendoza, J.A., Peña-Marín, E.S., Álvarez-González, C.A., López-Luna, M.A. and Maytorena-Verdugo, C.I. (2024). Digestive proteases of Morelet's crocodile (*Crocodylus moreletii*) in three life stages. *Revista de Biología Tropical* 72(1): e57126.

**Resumen:** Introducción: El cocodrilo de pantano (*Crocodylus moreletii*) es una especie distribuida en el sureste mexicano y amenazada por múltiples presiones. Objetivo: Caracterizar las proteasas digestivas en fase ácida (estómago) y fase alcalina (intestino) en tres etapas de vida de *C. moreletii* en cautiverio (cría, juvenil y adulto). Métodos: Se cuantificaron las actividades de proteasas alcalinas y ácidas totales utilizando caseína y hemoglobina como sustrato. Las actividades de tripsina, quimotripsina, leucina aminopeptidasa y elastasa se cuantificaron utilizando sustratos sintéticos. Los perfiles de proteasas se analizaron mediante SDS-PAGE y PAGE nativa. Resultados: La actividad específica de las proteasas ácidas y alcalinas mostró diferencias entre las tres

tallas, encontrándose la mayor actividad en el estadio juvenil. Las actividades de tripsina, quimotripsina, leucina aminopeptidasa y elastasa fueron mayores en las crías. Hubo diferencias en el pH y temperatura óptimos de las proteasas ácidas y alcalinas, tripsina y leucina aminopeptidasa entre las tres tallas, demostrando la diversificación de las enzimas según las diferentes tallas, así como la presencia de isoformas específicas en cada talla de *C. moreletii*. El zimograma en fase ácida mostró cuatro bandas con actividad similar a pepsina en la cría y juvenil, mientras que en el adulto solo se detectaron dos de las cuatro bandas. El zimograma alcalino mostró que la cría tuvo el mayor número de bandas de actividad en comparación con las otras tallas, correspondiente a la alta actividad específica reportada en la fase alcalina. Conclusiones: Las proteasas digestivas del cocodrilo de pantano presentaron características bioquímicas y en número de proteasas diferentes entre cría, juvenil y adulto. Esto podría ayudar en el futuro diseño de dietas balanceadas, así como al manejo y producción sustentable de esta especie.

**Abstract:** Introduction: Morelet's crocodile (*Crocodylus moreletii*) is a species distributed in the Mexican southeast and threatened due to multiple pressures. Objective: To characterize the digestive proteases in the acid phase (stomach) and alkaline phase (intestine) of three life stages of *C. moreletii* in captivity (hatchling, juvenile, and adult). Methods: Total alkaline and acid protease activities were quantified using casein and haemoglobin as substrates. Trypsin, chymotrypsin, leucine aminopeptidase, and elastase activities were quantified using synthetic substrates. Protease profiles were analysed by SDS-PAGE and Native-PAGE. Results: The specific activity of acid and alkaline proteases showed differences between the three stages, finding the highest activity in the juveniles. Trypsin, chymotrypsin, leucine aminopeptidase, and elastase activities were higher in hatchlings. There were differences in optimum pH and temperature of acid and alkaline proteases, trypsin, and leucine aminopeptidase between the three stages, demonstrating the diversification of the enzymes according to different stages, as well as the presence of specific isoforms in each stage of *C. moreletii*. The acid phase zymogram showed four bands with pepsin-like acid activity in the hatchling and juvenile crocodile, while in the adult only two of the four bands were detected. The alkaline zymogram showed that the hatchling had the highest number of activity bands compared to the other stages, corresponding to the high specific activity reported in the alkaline phase. Conclusions: Digestive proteases of Morelet's crocodile differ in their biochemical characteristics and the number of proteases between hatchling, juvenile, and adult. This could help in the future design of balanced diets as well to the sustainable management and production of this species.

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Lin, F-C., Lin, S-M. and Godfrey, S.S. (2024). Hidden social complexity behind vocal and acoustic communication in non-avian reptiles. *Proceedings of the Royal Society B* (<https://doi.org/10.1098/rstb.2023.0200>).

**Abstract:** Social interactions are inevitable in the lives of most animals, since most essential behaviours require interaction with conspecifics, such as mating and competing for resources. Non-avian reptiles are typically viewed as solitary animals that predominantly use their vision and olfaction to communicate with conspecifics. Nevertheless, in recent years, evidence is mounting that some reptiles can produce sounds and have the potential for acoustic communication. Reptiles that can produce sound have an additional communicative channel (in addition to visual/olfactory channels), which could suggest they have a higher communicative complexity, the evolution of which is assumed to be driven by the need of social interactions. Thus, acoustic reptiles may provide an opportunity to unveil the true social complexity of reptiles that are usually thought of as solitary. This review aims to reveal the hidden social interactions behind the use of sounds in non-avian reptiles. Our review suggests that the potential of vocal and acoustic communication and the complexity of social interactions may be underestimated in non-avian reptiles, and that acoustic reptiles may provide a great opportunity to uncover the coevolution between

sociality and communication in non-avian reptiles.

Scavezzoni, I. (2024). Girdle Anatomy of Aquatic Crocodylomorphs. PhD thesis, Université de Liège, Liège, Belgium.

**Abstract:** Nowadays, Crocodylomorpha is represented by twenty-eight species of semi-aquatic ambush predators with some of the more famous members including the saltwater crocodile, the gharial, and the American alligator. However, Crocodylomorpha was significantly more diverse in the past, as reported by its extensive fossil record. Unfortunately, craniodental remains have received much more attention, due to either historical reasons (i.e. lack of collected materials other than craniodental parts) or general contempt. As a result, the rich and complex postcranial anatomy of crocodylomorphs is little-known, further shrouding the locomotive adaptations that possibly underpinned their radiations and longevity. Recently, several works on different extinct clades of Crocodylomorpha have pointed out the necessity to refocus attention on postcranial anatomy in order to better understand both their lifestyle and their relationships. As such, this work tackles these issues and aspires to shed new light on the evolution of postcranial morphology of two extinct groups of aquatic crocodylomorphs: Thalattosuchia and Dyrosauridae. Thalattosuchia is a clade of secondarily aquatic crocodylomorph of uncertain phylogenetic origin. Thalattosuchia namely comprises the two very unique and distinct subclades: the mainly semi-aquatic Teleosauroida superficially resembling modern gharials and Metriorhynchoidea, which became highly aquatic. Dyrosaurids are nested within Neosuchia; they have relatively long ventral processes on their last cervical and anterior thoracic vertebra, and also possess markedly elongated neural spines in their thoracic region and all along their tail. Dyrosaurids also show a ventral and dorsal osteodermal shield and stout limb bones which may appear superficially similar to extant crocodylians at first glance. In this thesis, I thoroughly describe the postcranial anatomy (with a particular focus on girdles) of these clades in a comparative framework with extant crocodylians. I also use high-resolution 3D scanning and modelling to reconstruct the girdles of about 30 species. The main result of this thesis is that the postcranial anatomy of crocodylomorphs is distinctive and discriminating both interclade and intraclade. In addition, it is shown that extinct crocodylomorphs have developed distinct strategies in order to invade the aquatic realm, which are also dissimilar from other iconic marine reptiles like plesiosaurs and aquatic cryptodirans. Those claims are supported by several osteological observations and quantitative analyses (linear and 3D geometric morphometrics, phylogenetic inferences). Anatomical evidence, in particular proportions, suggest that the basal dyrosaurid *Carrejonisuchus improcerus* was mostly terrestrial and had a unique lifestyle which contrasts with that of other members of the clade. Thorough reinvestigation of the scapular pelvic girdle anatomy of Thalattosuchia and Dyrosauridae highlights the presence of major dissimilarities between and within those clades. These differences have functional implications, allowing me to postulate terrestrial walking and swimming capabilities. Geometric morphometrics analyses of the 3 dimensional models of the thoracic and pelvic girdles of Thalattosuchia and Dyrosauridae also reveals markedly distinct architectures between clades and clearly indicate that extant crocodylians are unsatisfactory functional analogues for ancient clades of Crocodylomorpha. The re-assessment of both thoracic and pelvic girdle anatomy also lead to the creation of 42 new postcranial phylogenetic characters along with the revision of several other postcranial characters taken in the literature. A new repurposed matrix centred on postcranial anatomy was built employing those characters. Results indicate that a clear phylogenetic signal resides in the postcranium of Crocodylomorpha. This signal partially differs from those recovered from cranial dominated datasets, further emphasizing the importance of postcranial anatomy in understanding the relations of extinct crocodylomorphs, in addition to their development, ecology, and biomechanics.

Chapata, T.E., Utete, B. and Chakandinakira-Furudzayi, A.T. (2024).

Assessing the drivers and barriers for gender participation and roles in rod and line angling along the shores of Sanyati Basin in Lake Kariba, Zimbabwe. Sustainable Environment (<https://doi.org/10.1080/27658511.2024.2345451>).

**Abstract:** Small-scale fisheries support numerous livelihoods in Zimbabwe. However, men are the key actors in the fishing sector relegating women to peripheral roles, often, diminishing women's contribution to household economy and food security. This study investigated the (i) gendered nature of rod and line angling fisheries, (ii) drivers and barriers for gender roles and participation in rod and line angling fisheries, and (iii) household contribution of rod and line angling fisheries in Lake Kariba. The level of participation in fishing, and postharvest roles such as gutting, gleaning, drying, and smoking significantly differs ( $p < 0.05$ ) among men and women fishers. The main drivers for engaging in rod and line angling for both men and women were a need for food security, extra income, employment, and mental health benefits. The main barriers discouraging rod and line angling were conflict with hippos, crocodiles, expensive fishing permits, park enforcement of strict fishing zones and proper gear, prohibitive costs of fishing equipment, and decline in market demand for fish. Gender does not significantly ( $p > 0.05$ ) influence the opinions of the fishers towards the drivers and barriers for engaging in rod angling. Women dominate men in numbers and the roles they play, though they have inadequate decision-making powers and hardly get the recognition they deserve in the rod and line angling value chain in Lake Kariba. Developing a pro-women National Fisheries and Aquaculture Policy in Zimbabwe will uplift and empower women fishers in contributing to household food security and poverty alleviation in small-scale artisanal fisheries.

Poapolathep, S., Escudero, E., Klangkaew, N., Phaochoosak, N., Wongwaipairoj, T., Marin, P. and Poapolathep, A. (2024). Pharmacokinetics of tildipirosin in estuarine (*Crocodylus porosus*) and freshwater (*Crocodylus siamensis*) crocodiles. The Veterinary Journal 305 (<https://doi.org/10.1016/j.tvjl.2024.106130>).

**Abstract:** Tildipirosin is a macrolide antimicrobial. It is authorised for the treatment and prevention of respiratory disease in cattle and pigs. There are no data on its administration in crocodiles. Therefore, this study evaluated the disposition kinetics of tildipirosin after intravenous (dose: 2 mg/kg) and intramuscular (doses: 2 and 4 mg/kg) administration in two crocodilian species (estuarine and freshwater;  $n = 5$ ). Tildipirosin plasma concentrations were quantified by a validated HPLC method. Plasma concentrations obtained at each extraction time were analysed by non-compartmental methods. In the estuarine and freshwater crocodiles, the apparent volumes of distribution of tildipirosin after intravenous administration were  $0.36 \pm 0.10$  and  $1.48 \pm 0.26$  L/kg, respectively. These values, suggesting poorer tissue distribution, were much lower than those obtained in mammals. There was complete bioavailability of tildipirosin after intramuscular route at a dose of 2 mg/kg; however, at a dose of 4 mg/kg the bioavailability decreased by about 20-25 %. Furthermore, the pharmacokinetics of tildipirosin were markedly different in the two crocodilian species. Considering a MIC of  $0.5 \mu\text{g/mL}$ , the surrogate marker  $\text{AUC}_{0-24}/\text{MIC}$  indicates that tildipirosin would greatly exceed the value of 65 h for both crocodile species and dose levels tested. This suggests that both doses (2 and 4 mg/kg) may provide a bactericidal effect. Therefore, based on the absence of adverse reactions following the administration of tildipirosin in both crocodilian species, and considering its favourable pharmacokinetic properties, tildipirosin may be useful in treating infections in these reptiles.

Gvoždík, V., Dolinay, M., Zassi-Boulou, A-G., Lemmon, A.R., Lemmon, E.M. and Procházka, M. (2024). Central African dwarf crocodiles found in syntopy are comparably divergent to South American dwarf caimans. Biology Letters 20(5) (<https://doi.org/10.1098/rsbl.2023.0448>).



**Abstract:** Recent molecular taxonomic advancements have expanded our understanding of crocodylian diversity, revealing the existence of previously overlooked species, including the Congo dwarf crocodile (*Osteolaemus osborni*) in the central Congo Basin rainforests. This study explores the genomic divergence between *O. osborni* and its better-known relative, the true dwarf crocodile (*Osteolaemus tetraspis*), shedding light on their evolutionary history. Field research conducted in the northwestern Republic of the Congo uncovered a locality where both species coexist in sympatry/syntopy. Genomic analysis of sympatric individuals reveals a level of divergence comparable to that between ecologically similar South American dwarf caimans (*Paleosuchus palpebrosus* and *Paleosuchus trigonatus*), suggesting parallel speciation in the Afrotropics and Neotropics during the Middle to Late Miocene, 10–12 Ma. Comparison of the sympatric and allopatric dwarf crocodiles indicates no gene flow between the analysed sympatric individuals of *O. osborni* and *O. tetraspis*. However, a larger sample will be required to answer the question of whether or to what extent these species hybridize. This study emphasizes the need for further research on the biology and conservation status of the Congo dwarf crocodile, highlighting its significance in the unique biodiversity of the Congolian rainforests and thus its potential as a flagship species.

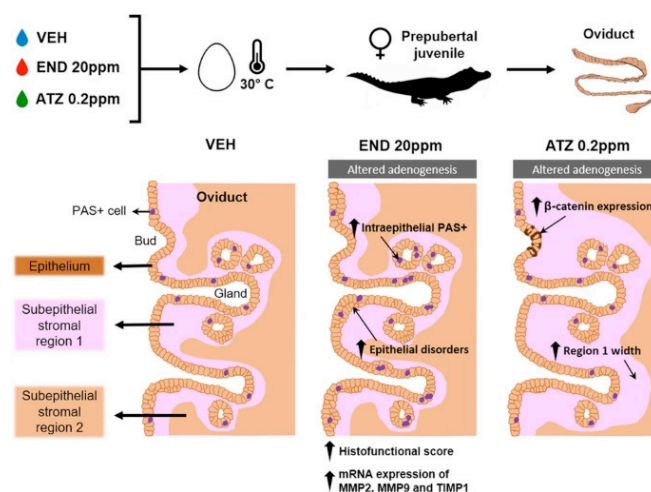
Clancy, T.F., Welch, M. and Fukuda, Y. (2024). Management Program for the Saltwater Crocodile (*Crocodylus porosus*) in the Northern Territory of Australia, 2024–2034. Department of Environment, Parks and Water Security: Palmerston.

Tuten, C. (2024). The Influence of Researcher Disturbance on Raccoon Predation of American Alligator Nests. MSc thesis, Coastal Carolina University, South Carolina, USA.

**Abstract:** Raccoons (*Procyon lotor*) are a dominant predator of American alligator (*Alligator mississippiensis*) nests in the southeastern United States, using a combination of olfactory, visual, and tactile cues to identify nest locations. Studies on alligator nesting ecology typically require researchers to create paths through marsh habitat, potentially introducing visual and olfactory cues raccoons may use to locate nests. The purpose of this study was to evaluate the effect of human visitation to alligator nests on the frequency of raccoon nest predation at two sites in coastal South Carolina, Tom Yawkey Wildlife Center (TYWC) and Santee Coastal Reserve (SCR). We hypothesized that human foot traffic associated with nest monitoring increases the frequency of nest predation by raccoons. We observed a non-significant trend toward higher predation of foot-visited nests compared to drone and non-visited nests independent of study site (Mehta and Patel,  $p = 0.261$ ). This trend was similar at both study sites (Mehta and Patel, TYWC  $p = 0.106$ , SCR  $p = 1$ ). When comparing predation by nest access method (ie boat, drone, foot, no-access), there was an overall non-significant trend towards higher predation of foot-visited nests independent of study site (Mehta and Patel,  $p = 0.255$ ). TYWC experienced higher predation of foot-accessed nests (Mehta and Patel,  $p = 0.031$ ) while SCR experienced lower predation of foot-accessed nests (Mehta and Patel,  $p = 1$ ). These results suggest that at sites of long-term nesting research (eg TYWC), alternative access methods may be useful in mitigating olfactory or visual cues left by researchers. Post-hoc power analyses, however, indicate low statistical power for our comparisons (Nest Predation by Treatment Group: 33.15%, vs Nest Predation by access method: 29.62% predation). Overall, the results of this study suggest raccoons may use human cues to locate alligator nests; however, replication of the study across multiple seasons to increase sample size would help to further examine this hypothesis.

Tavalieri, Y., Alarcon, R., Tscopp, M., Luque, E., Munoz-de-Toro, M. and Galoppo, G. (2024). Exposure to atrazine and endosulfan alters oviductal adenogenesis in the broad-snouted caiman (*Caiman latirostris*). Environmental Science and Pollution Research 31(24): 35927–35937

**Abstract:** The molecular pathways involved in oviductal adenogenesis are highly conserved among vertebrates. In this work, we study the histomorphological changes and molecular pathways involved in *Caiman latirostris* oviductal adenogenesis and the effects of *in ovo* exposure to environmentally relevant doses of endosulfan (END) and atrazine (ATZ) on these processes. To this end, the histomorphological changes at epithelial and subepithelial compartments, the protein expressions of  $\beta$ -catenin and Wnt-7a, and the gene expression of metalloproteinases (MMPs) and its inhibitors (TIMPs) were evaluated as biomarkers of oviductal adenogenesis in prepubertal juvenile *C. latirostris*. Exposure to END altered adenogenesis-related epithelium characteristics and mRNA expression of MMP2, MMP9, and TIMP1. Exposure to ATZ increased the width of the subepithelial stroma with loosely arranged collagen fibers and increased  $\beta$ -catenin expression in buds (invaginated structures that precede glands). The results demonstrate that *in ovo* exposure to ATZ and END alters oviductal adenogenesis at tissue, cellular, and molecular levels. An altered oviductal adenogenesis could impair fertility, raising concern on the effects of pesticide pollution in wildlife and domestic animals.



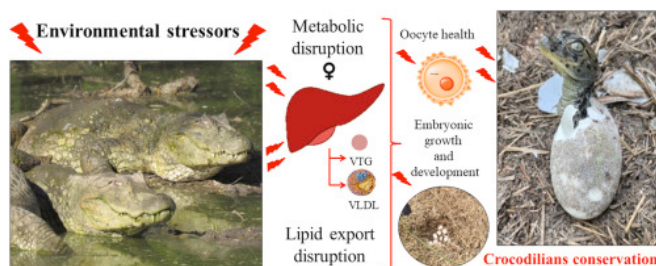
Ciocan, H., Hilevski, S., Príncipe, G. and Siroski, P. (2024). Body condition factor for Broad-snouted caiman, *Caiman latirostris* (Daudin, 1802). Herpetology Notes 17: 285–290.

**Abstract.** The Fulton coefficient (K) is an index of body condition that relates length and weight, indicates relative fatness and was designed to determine growth in fish. Various animal studies employ the Body Condition Factor (BCF) as a metric to assess the physical well-being of an individual. This index enables the inference of an individual's relationship with the environmental conditions and its growth. In addition, the BFC is used to compare populations across various locations or to examine how some unique animal population, such as of crocodilians, varies over time. However, the index value is not attributed to individuals and its only employed to compare K values among them. In this study, our aim was to generate reference values for the K index to classify individuals of *Caiman latirostris* according to their physical condition. We did this by categorizing individuals as skinny, good or fat and, then associating them to their respective K values to further establish a K range that relates with the physical condition of the species. We then conducted non-parametric tests to determine the fit of K values to the classification. These results can serve as reference values for individual conditions for the species, and would be of use in several population studies.

Chacon, C.F., Parachu Marco, M.V., Poletta, G.L. and Siroski, P. (2024). Lipid metabolism in crocodilians: A field with promising applications in the field of ecotoxicology. Environmental Research 252(4) (<https://doi.org/10.1016/j.envres.2024.119017>).

**Abstract:** In the last years, lipid physiology has become an

important research target for systems biology applied to the field of ecotoxicology. Lipids are not only essential components of biological membranes, but also participate in extra and intracellular signaling processes and as signal transducers and amplifiers of regulatory cascades. Particularly in sauropsids, lipids are the main source of energy for reproduction, growth, and embryonic development. In nature, organisms are exposed to different stressors, such as parasites, diseases and environmental contaminants, which interact with lipid signaling and metabolic pathways, disrupting lipid homeostasis. The system biology approach applied to ecotoxicological studies is crucial to evaluate metabolic regulation under environmental stress produced by xenobiotics. In this review, we cover information of molecular mechanisms that contribute to lipid metabolism homeostasis in sauropsids, specifically in crocodilian species.



Ceríaco, L.M.P., Barbosa, M.R., Sousa, A.C.A., Santos, B.S., Perestrelo, S. and Marques, M.P. (2024). Arrival of crocodilians to São Tomé Island, Gulf of Guinea, Western Africa, highlights the role of sea currents to the natural colonization of islands. *Amphibia-Reptilia* 45(2): 247-255.

**Abstract:** Historical and recent arrivals of crocodilians to the Gulf of Guinean Oceanic Island of São Tomé have intrigued naturalists for several centuries. Here we present the revision of the historical records, and present data regarding the recent arrival of a single specimen in 2021. After being killed by the local authorities, the specimen was preserved and studied both through morphological and molecular methods. Our findings suggest that the specimen was a sub-adult Nile crocodile, *Crocodylus niloticus* Laurenti, 1768, which most likely drifted from the Congo or Ogooué River mouths in West Africa by the oceanic current acting on the Gulf of Guinea. The story of this individual highlights the dispersion paths that have contributed by the past biological colonization of São Tomé Island.

Green, A.R., Plowman, C., Mwinyihali, R., Wieland, M. and Gore, M.L. (2024). Women and urban wildmeat trafficking in the Republic of Congo. *Biological Conservation* 293 (<https://doi.org/10.1016/j.biocon.2024.110587>).

**Abstract:** As a result of declining biodiversity and increasing rates of urbanization, the illegal urban wildmeat trade is projected to become an integral sector of the wildlife crime industry. Adequate assessment of urban wildmeat trafficking requires investigation into the roles and behaviors of individuals who engage in wildlife crimes. However, akin to much of wildlife crime literature, women's engagement within the urban wildmeat trade have received little investigation. The objectives of our investigation were to (1) explore relationships between women and wildlife products across the supply chain, and (2) determine whether a significant relationship exists between women and specific wildlife products. Through systematic social observations, we evaluate the gendered dimensions of urban wildmeat trafficking in the Republic of Congo between the urban centers of Brazzaville and Pointe-Noire. We place particular emphasis on species of conservation concern, namely great apes, African pangolins, and dwarf crocodiles. Results indicate that there are gendered variations at the species and the geographic level, indicating that women are sourcing and sending their products to different locations than men, and that women are specializing in trade of different species. We attest that urban wildmeat trafficking

prevention strategies implement a gender-aware approach due to the unique ways that individuals engage with the industry and how that engagement is gendered.

Pérez-Fleitas, E. and Sosa Rodríguez, G. (2024). Feral cats, a new threat to the Cuban Crocodile, *Crocodylus rhombifer* Cuvier, 1807 in Cuba? *Herpetology Notes* 17: 225-227.

Woodward, H.N., Aubier, P., Araújo de Sena, M.V. and Cubo, J. (2024). Evaluating extinct pseudosuchian body mass estimates using a femur volume-based model. *The Anatomical Record* (<https://doi.org/10.1002/ar.25452>).

**Abstract:** The clade Pseudosuchia appeared 250 million years ago. The exclusively semi-aquatic Crocodylia, which includes crocodiles, alligators, caimans, and gharials is the only surviving subgroup. Investigating Crocodylia biology is pivotal for inferring traits of extinct pseudosuchians. *Alligator* femur length is widely used for modeling pseudosuchian body mass, but the regression is influenced by sex and captivity status, leading to potential accuracy problems. An alternative model results from the correlation between alligator femur volume and body mass, which is unaffected by those covariates. Here, an alligator femur volume-based regression is applied to estimate the masses of non-crocodylian pseudosuchians, encompassing goniopholid, dyrosaur, notosuchian, and thalattosuchians. For each, femur volume as the predictor yields lower body masses than does femur length. Morphological resemblances to existing crocodylians support the inference that extinct goniopholid and dyrosaur were semi-aquatic. Therefore, body masses predicted from femur length and volume should be reasonable, although larger body masses obtained from femur length may reflect sensitivity to sex or environmental factors. Fully terrestrial notosuchians had proportionately longer femora for their body sizes compared to semi-aquatic crocodylians, suggesting that the higher body masses predicted from alligator femur length are overestimates. Fully aquatic thalattosuchians, skeletally adapted for buoyancy and with reduced reliance on the femur for locomotion, pose challenges for both femur length and volume-based models. The results of this study advocate for the use of femur volume to predict body mass, particularly for semi-aquatic and terrestrial pseudosuchians, and encourage further exploration of volumetric models as body size predictors for extinct vertebrates.

Hilevski, S., Manolis, C. and Siroski, P. (2024). A true facultative carnivore? Effects of replacing ground chicken carcasses with soybean meal on the growth of captive broad-snouted caiman (*Caiman latirostris*) and its economics implications. *Animal Physiology and Animal Nutrition* (<https://doi.org/10.1111/jpn.13958>).

**Abstract:** A specific diet for broad-snouted caiman, *Caiman latirostris* has not been designed despite the value of farm-raised caiman as an aquaculture product. To fill this gap, the objectives of this study were to evaluate the performance dietary replacement of ground chicken carcasses by of soybean meal (SM) as diet complement for *C. latirostris*. We conducted a 3-month growth trial to determine effects of graded levels of dietary SM on caiman growth as measured by increase in body length, body weight gain, food consumption (FC) and food conversion rate (FCR). Forty-eight hatchling caimans were fed with diets, composed primarily of practical feed ingredients, with 0, 25, or 40% dietary SM. Diets were fed three times per week for 90 days under temperature controlled. Body lengths and body weights were measured at 30-day intervals, and FC samples were taken between the 31-60-day interval. The results of this study indicate that the inclusion of SM in the diet of *C. latirostris* at levels of 25% increases in body length, body weight gain, FC and improve the FCR indicated that a concentration of 25% dietary SM (as fed) was adequate for growth of caimans under the conditions of this study. Results suggest that SM have a

real nutritional contribution in the diet of broad-snouted caiman and can be used as an ingredient of the diet of the crocodilians raised in captivity, reducing production costs for sustainable use and conservation programs of this species.

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Pooley, S. (2024). Research and management of the Nile crocodile (*Crocodylus niloticus*) in Ndumo Game Reserve. African Journal of Wildlife Research

**Abstract:** This paper provides background on human interactions with Nile crocodiles (*Crocodylus niloticus*) in the Ndumo region from the 1890s, through to the period of formal conservation in Ndumo Game Reserve from c.1951. It explains how serious population declines in the 1950s-60s led the Natal Parks, Fish and Game Preservation Board to prioritize crocodile research and conservation in this reserve. The work of Tony (A.C.) Pooley from 1962-74 is discussed, a foundational period for crocodile research and conservation in South Africa, in which Ndumo became renowned for crocodile research and conservation, with its Experimental Crocodile Restocking Station. Research and conservation management were intertwined throughout this period, and both are profiled as they unfolded in the reserve. Next, the period from the 1980s to the present is discussed, including periods under KwaZulu Bureau of Natural Resources and Ezemvelo KZN Wildlife management. The paper concludes with a brief reflection on the management challenges of the current situation, including habitat destruction within the game reserve, population decline (data are provided for all recorded annual counts), locals' attitudes to crocodiles, and seasonal movements of crocodiles between South Africa and Mozambique.

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Brackhane, S., Fukuda, Y., Xavier, F.M.E., De Araujo, V., Gusmao, M., Trindade, J., De Carvalho, D. do A., Pires, R.D.R. and Webb, G. (2024). Wildlife conservation through traditional values: alarming numbers of crocodile attacks reported from Timor-Leste. *Oryx* (doi:10.1017/S0030605324000036).

**Abstract:** On the IUCN Red List the saltwater crocodile *Crocodylus porosus* is categorized globally as Least Concern, with national populations ranging from fully recovered to extinct. The saltwater crocodile population of the Southeast Asian island nation of Timor-Leste was severely depleted by colonial hunting but has recovered since independence in 2002. During 2007-2014 there was a 23-fold increase in reported crocodile attacks (104 documented attacks), concomitant with a 2% annual increase in the human population. Public tolerance to attacks and the reluctance to harm crocodiles are entwined with reverence of crocodiles as sacred beings by most but not all Timorese people. In 2022, 7-8 years after our previous assessment, we visited five sites on the south coast of Timor-Leste in Lautém, Viqueque, Manufahí and Cova Lima municipalities. High rates of crocodile attacks continue. We obtained 35 records of attacks for 2015-2022 (34% fatal). In the municipalities where crocodile attacks occurred (Lautém, Viqueque, Cova Lima), the sacred status of crocodiles prevented inhabitants from harming them in retribution. In Manufahí, where no attacks were reported, such traditional values never existed and crocodiles were hunted for subsistence and to improve safety. The design of a context-specific crocodile management programme that respects the reverence attributed to crocodiles by most people but reduces the risk of people being attacked by crocodiles is a conservation management challenge for the Government of Timor-Leste. The developing tourism industry, which relies on coastal beaches and reefs, is jeopardized by the risk of crocodile attacks.

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Letnic, M., Dempster, T., Jessop, T.S. and Webb, J.K. (2024). Imperfect adaptation by freshwater crocodiles to the invasion of a toxic prey species. *Biological Invasions* 26: 1941-1955.

**Abstract:** Novel interactions between invaders and native species

that have evolved in their absence may impose strong selective pressures that drive species to extinction or prompt rapid co-evolution and learning. Here, we report on the effects that invasive cane toads, a toxic prey species, have had on freshwater crocodile populations in 7 waterholes of the Victoria River, Australia, before and up to 14 years after toads invaded. We recorded observations of crocodiles attacking toads, dissected dead crocodiles to determine if they had eaten toads and indexed the abundances of cane toads, live crocodiles and dead crocodiles. Following toad-invasion we observed crocodiles attacking cane toads. Dead crocodiles were only observed following the invasion of toads and 62% of the 71 dead crocodiles we dissected had toads in their stomachs. Counts of dead crocodiles showed a humped relationship with time since toad invasion and declined markedly after 3 years post-toad invasion. Live crocodile abundance declined sharply following toad-invasion, but this decline attenuated approximately 4 years post-invasion. The pulse of crocodile mortality and attenuation of the rate of crocodile population decline suggests that crocodiles have evolved or learned to enable co-existence with toads. However, crocodile populations have shown no sign of recovery in the 8-14 years post toad invasion. Our findings highlight that adaptation by native species to the presence of invaders may be imperfect and thus may not necessarily entail numerical recovery of populations to pre-invasion levels, but instead downward shifts to new equilibria due to ongoing interactions with invaders.

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Roque, N., Gross, B., Rodriguez-Cordero, A.L., Balaguera-Reina, S.A. and Densmore III, L.D. (2024). First confirmed record of Spectacled Caiman, *Caiman crocodilus* Linnaeus 1758, in the Department of Pando, Bolivia. *Reptiles & Amphibians* 31(1): e21738

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Khadka, B.B., Bashyal, A. and Griffith, P. (2024). Population changes in Gharial (*Gavialis gangeticus*) vary spatially in Chitwan National Park, Nepal. *Reptiles & Amphibians* 31(1): e21018.

**Abstract:** Gharials, large crocodilians found only in South Asia, are widely seen as a flagship species for river conservation in Nepal, especially in Chitwan National Park, where a headstart program has supplemented the population since 1981. The population has shown signs of recovery only in the last decade, so continued monitoring of population trends is vital for conservation. We conducted annual winter population surveys for Gharial in Chitwan between 2017 and 2022, during which we also characterized riverbank substrate availability and basking preferences. We documented potential threats to the species in Chitwan throughout the year. Overall, we counted an increasing number of Gharials in Chitwan; however mixed-effects modelling of Gharial encounter rate showed that increasing encounter rates are not evenly distributed throughout available habitat, with some river stretches having stable or decreasing trends. Encounter rates on the Rapti River increased in all transects, compared to more variable results on the Narayani River, likely attributable to higher levels of human disturbance and the impact of captivity on habitat selection. Fewer Gharials were seen in transects with high levels of disturbance due to sand mining and the extraction of river substrates, highlighting this threat as a major concern. Regular reports of bycatch in illegal gillnets was the major observed source of mortality. A lack of an increasing population trend in the stretch above a large barrage suggests that recruitment is minimal in this area, and the dam likely has a negative impact on upstream Gharial recruitment. We cautiously suggest that the Chitwan population is recovering, but that recovery is hampered by threats, especially substrate extraction, illegal gillnet fishing, and river fragmentation by a dam.

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Ugemuge, S., Badhawan, A.D., Gupta, P. and Vashistha, G. (2024). Twinning in a wild breeding population of Gharials (*Gavialis gangeticus*) in India. *Reptiles & Amphibians* 31(1): e21619.



Draper, C., Lewis, C., Jayson, S. and Osuch, F. (2024). Private keeping of dangerous wild animals in Great Britain. *Animals* 14(10): 1393

**Abstract:** We analysed the licences issued by British local government authorities under the Dangerous Wild Animals Act 1976, which regulates the private keeping of wild animals categorised as “dangerous”, to assess the scope and scale of private keeping of dangerous wild animals in Great Britain. Results are compared with historical data from England and Wales, showing that there has been an overall decrease both in the total population of dangerous wild animals privately kept under licence and the number of licences, resulting primarily from a decrease in the farming of wild boar and ostrich, and from certain other species no longer requiring a licence to be kept. Nonetheless, the private keeping of dangerous wild animals remains prevalent, with a total population of 3950 animals kept under licence, and at least one-third of local authorities in Britain licensing keepers of one or more such animals. The population of non-farmed dangerous taxa has increased by 59% in 20 years, with notable increases in crocodilians (198%), venomous snakes (94%), and wild cats (57%). We present evidence that the average cost of a licence to keep dangerous wild animals has fallen over time, and that there is a negative association between cost and licensing. The current schedule of species categorised as dangerous is compared to a formally recognised list of species kept in zoos assessed by risk to the public. Problems with the legislation, enforcement of the licensing system, and animal welfare for privately kept dangerous wild animals are identified and discussed.

Siroski, P.A., Ciocan, H., Hilevski, S. and Larriera, A. (2024). Increasing population status of Broad-snouted caiman (*Caiman latirostris*) based on sustainable use strategies in a managed protected area in Santa Fe, Argentina. *Animals* 14(9): 1288.

**Abstract:** People and crocodilians have engaged in interactions since the earliest human settlements. After many years of escalating non-regulated use, coupled with emerging threats such as habitat modification, environmental pollution, and the exponential growth of human populations, natural crocodilian populations have been pushed to the brink of extinction. To prevent this, various initiatives have implemented strategies to prevent local extinction. Reinforcing wild populations through reintroductions and head-starting programs has been considered the safest approach to recovering crocodilian populations. Subsequently, the concept of sustainability emerged. In the case of many historically exploited crocodilian species, it became evident that rational utilization need not adversely affect population status; on the contrary, there were clear signs of recovery when local communities were involved. In 1990, the broad-snouted caiman (*Caiman latirostris*) was in a critical state due to decades of poaching and the aforementioned threats. In response, the “Monitoring and restocking program of the broad-snouted caiman for management purposes”, commonly known as Proyecto Yacaré, was established to study population abundance and assess the biological, ecological, and social response to this management methodology. As a result of the eggs’ harvest, a proportion equivalent to or greater than what would have survived in natural conditions was released into the original habitat where the eggs were collected. The surplus was allocated for leather and meat production with a focus on economic and environmentally sustainable practices, without affecting biodiversity or threats to the managed species. The in situ work carried out by this program has been crucial for the recovery of broad-snouted caiman populations under the “incentives for conservation” system, whereby local communities receive benefits for nest identification and egg harvesting. Over time, conservation incentives have become significant contributors to regional economies. This study illustrates how *C. latirostris* populations increased due to the implementation of egg harvesting by local communities in a natural reserve for management purposes. This population increase was detected through continuous night monitoring and an analysis of the number of nests in the area. Currently, *C. latirostris* populations have transitioned from being among the most threatened to becoming one

of the most abundant throughout their distribution area. Based on the analyzed information, we may affirm that the commercial value of these species is one of the most relevant aspects contributing to the sustainability of these programs, primarily due to the change in perception generated among local communities. Therefore, identifying and controlling factors affecting these programs are fundamental for the conservation of these species.

Queiroz Luz Hirano, L., Rodrigues de Oliveira, A.L., Ferraz de Barros, R., Costa Veloso, D.F.M., Martins Lima, E., Quagliatto Santos, A.L. and Duque Moreno, J.C. (2024). Pharmacokinetics and pharmacodynamics of dextroketamine alone or combined with midazolam in *Caiman crocodilus*. *Journal of Veterinary Pharmacology and Therapeutics* (<https://doi.org/10.1111/jvp.13447>).

**Abstract:** Pharmacokinetics studies of anesthetic agents are important for understanding of the pharmacology and metabolism of anesthetic agents in reptilians. This study was designed to examine the pharmacokinetic and pharmacodynamic properties of intravenous dextroketamine alone or combined with midazolam in *Caiman crocodilus*. Eight caimans were anesthetized with dextroketamine (10 mg/kg; group D) or dextroketamine and midazolam (10 and 0.5 mg/kg respectively; group DM) into the occipital venous sinus. The pharmacokinetic parameters were calculated by HPLC using a non-compartmental modeling. Serial blood samples were collected at baseline and within 15 and 30 min, and 11.5, 2, 4, 8, 12, 24 and 48 h of drug administration. Sedation status over time differed between groups. All animals in group D (8/8; 100%) showed signs of light sedation at t10. Half (4/8; 50%) of these caimans did not progress to deeper levels of sedation. In spite of light sedation at t10, animals in group DM were deeply sedated within  $13.13 \pm 7.04$  min of anesthetic agent injection. The area under the plasma concentration–time curve ( $AUC_{0-48}$ ) and half-life of dextroketamine changed significantly after combination with midazolam. Even without significant changes in clearance, the almost two-fold increase in the half-life of dextroketamine suggests a slower rate of elimination.

Bashyal, A., Shrestha, N., Thapa, R., Shrestha, S., Sanjel, M., Densmore, L.D. and Khadka, B. (2024). Nesting of the critically endangered gharial *Gavialis gangeticus* in Bardia National Park, Nepal. *Oryx* 58(3): 340-343.

**Abstract:** The Gharial *Gavialis gangeticus* is a Critically Endangered crocodilian currently known from only 14 disjunct locations in Nepal and India. The protected stretch of the Babai River in Bardia National Park, Nepal, is home to one of the six subpopulations of Gharials that have exhibited recent evidence of reproduction. However, there is limited information available on the gharial population in this region. We conducted surveys during the breeding, nesting and hatching seasons of Gharials during 2020-2022 to study the Gharial population in the Babai River in Bardia National Park. We located one breeding group of Gharials in Soth Khola (2-3 individuals) and one in Dhanuse (5-6 individuals), and we observed pre-mating or mating behaviours in all 3 years. We identified potential nesting areas on sand banks of 19-175 m in length. During nesting seasons we found abundant signs of nesting only in Dhanuse, including entry and exit trails of female gharials to and from the water and trial nests. In 2020 and 2021 we did not find any signs of hatching, probably because of flooding. In 2022 we recorded two gharial nests, producing c. 60 hatchlings, in Dhanuse. Our findings indicate that the Gharial population in the Babai River is probably nesting annually. We recommend various conservation actions for this Gharial population.

Pereyra, M.E., Bona, P., Siroski, P. and Chinsamy, A. (2024). Ontogenetic and interelemental study of appendicular bones of *Caiman latirostris* Daudin, 1802 sheds light on osteohistological variability in crocodylians. *Journal of Morphology* (<https://doi.org/10.1002/jmor.21687>).



**Abstract:** The osteohistology of vertebrates provides a reliable source to deduce biological information, particularly regarding growth and development. Although osteohistological studies in Neosuchia (Crocodyliformes, Mesoeucrocodylia) are relatively numerous, the number of species studied within the group is still small. Extant crocodylians are known to exhibit intraspecific variability linked to environmental conditions, habitat, feeding, and other intrapopulation factors. Here, we analyzed the osteohistology of the living South American *Caiman latirostris* throughout posthatching ontogeny. The histology of several appendicular bones of 13 different-sized captive and wild individuals were examined. Although some thin sections revealed the classic lamellar, parallel-fibered, or woven bone matrices, others showed a variation and a mix between the organization of the bone tissue. These histological differences are likely related to variability in the growth dynamics of caimans. In some bones of the juveniles studied, remnants of embryonic bone were observed. Osteohistological variation related to prevailing environmental conditions is documented. Furthermore, our results show ontogenetic variation in the type of bone tissues deposited throughout the development of *C. latirostris*. This study offers a broad framework for life history interpretations for *C. latirostris* and provides insight into the evolutionary history and ontogenetic growth of extinct crocodylian lineages.

Silva, P.R. da. (2024). Convergência funcional entre os crocodilianos de rostrum curto *Paleosuchus* (Alligatoridae) e *Osteolaemus* (Crocodylidae) com base em análise de elementos finitos. MSc thesis, Universidade Estadual Paulista, São José do Rio Preto, Brazil.

**Resumo:** A morfologia do crânio dos crocodilianos (Crocodyliformes, Crocodylia) se modificou profundamente ao longo da história evolutiva do grupo, sendo que tais mudanças foram atribuídas a diversos fatores como a hidrodinâmica e hábitos de predação. Os crânios de morfologia platirostrais, achatados dorsoventralmente, são observados na maioria dos táxons vivos, como em *Alligator*, *Caiman*, e *Crocodylus*, enquanto que a morfologia oreinirostral, elevada dorsoventralmente, são características apenas dos táxons *Paleosuchus* (Alligatoridae) e *Osteolaemus* (Crocodylidae). *Paleosuchus* habita o continente sul-americano, enquanto *Osteolaemus*, é endêmico das florestas tropicais africanas. Esta peculiaridade entre ambos é considerada exemplo de convergência evolutiva, ou seja, a morfologia craniana foi obtida independentemente através de pressões seletivas similares, porém não há estudos que visam a coleta de evidências que corroborem esta hipótese. Assim, o objetivo deste trabalho é utilizar modelagem in silico com base em reconstruções tridimensionais craniomandibulares de *Paleosuchus* e *Osteolaemus*, visando reconhecer padrões morfofuncionais convergentes. Para isso, foi empregado a Análise de Elementos Finitos nos dois táxons alvos e uma série de táxons de Crocodylia, para modelar cenários biomecânicos extrínsecos (respostas dos modelos as forças externas) e intrínsecos (forças musculares adutoras da mandíbula). Posteriormente, decodificar a interpretação destes cenários em gradiente de cores com intuito de identificar padrões e quantificar o stress de Von Mises para cada cenário. *Osteolaemus* e *Paleosuchus* registraram similaridade em distribuições de stress no crânio e divergiram de táxons com outras morfologias cranianas. *Osteolaemus* também registra uma proximidade relevante com Alligatoridae, reforçando a hipótese de a forma deste táxon ser similar aos aligatídeos. Entretanto, a mandíbula de *Paleosuchus* exibiu um padrão único de stress, assemelhando-se aos demais apenas no cenário shake. A mandíbula é uma estrutura intimamente ligada com forças musculares provenientes da predação, e não possui funções extras como a proteção de órgãos do crânio. A presença de hábitos mais terrestres tornou a mandíbula de *Paleosuchus* distinta dos demais táxons. Portanto, a convergência funcional entre *Osteolaemus* e *Paleosuchus* no presente trabalho limitou-se ao crânio.

**Abstract:** The morphology of crocodylian skull (Crocodyliformes, Crocodylia) has changed profoundly throughout the evolutionary history of the group. Such changes have been attributed to several

factors such as hydrodynamics and predatory habits. Skulls presenting platyrostral morphology, i.e. dorsoventrally flat, are observed in most living taxa, including *Alligator*, *Caiman* and *Crocodylus*, while oreinirostral morphology, i.e. dorsoventrally high, are observed only in *Paleosuchus* (Alligatoridae) and *Osteolaemus* (Crocodylidae). *Paleosuchus* inhabits the South American continent, while *Osteolaemus* is endemic to African rainforests. This peculiarity between the two is considered an example of evolutionary convergence, i.e. cranial morphology was obtained independently through similar selective pressures. However, there are no studies that aim to collect evidence that corroborates this hypothesis. So, the objective of this work is to apply in silico modeling based on three-dimensional craniomandibular reconstructions of *Paleosuchus* and *Osteolaemus*, aiming to recognize convergent morphofunctional patterns. For this, Finite Element Analysis was used on the two target taxa and a series of additional crocodylian taxa, to model extrinsic (model responses to external forces) and intrinsic (jaw adductor muscle forces) biomechanical scenarios, decoding these scenarios in gradient of colors in order to identify patterns and quantify Von Mises stress for each scenario. *Osteolaemus* and *Paleosuchus* recorded similarity in stress distributions in the skull and diverged from taxa with different cranial morphologies. *Osteolaemus* also records a relevant proximity to Alligatoridae, reinforcing the hypothesis that the form of this taxon is similar to what is observed in alligatorids. However, the jaw of *Paleosuchus* exhibited a unique stress pattern, resembling the others only in the shake scenario. The jaw is a structure closely linked to muscular forces arising from predation, as it does not have extra functions such as protecting skull organs, therefore, the presence of more terrestrial habits made the jaw of *Paleosuchus* distinct from other taxa. Consequently, the functional convergence between *Osteolaemus* and *Paleosuchus* is limited to the skull.

Anderson, J.F., Molaei, G., Fish, D., Armstrong, P.M., Khalil, N., Brudner, S., Misencik, M.J., Bransfield, A., Olson, M. and Andreadis, T.G. (2021). Host-feeding behavior of mosquitoes in the Florida Everglades. Vector-Borne and Zoonotic Diseases (<https://doi.org/10.1089/vbz.2023.007>).

**Abstract:** West Nile virus (WNV), Everglades virus (EVEV), and five species of *Orthobunyavirus* were isolated from mosquitoes collected in the Everglades in 2016-2017. Prior studies of blood meals of mosquitoes in southern Florida have related findings to acquisition and transmission of EVEV, St. Louis encephalitis virus, and WNV, but not the *Orthobunyavirus* viruses associated with the subgenus *Melanoconion* of the genus *Culex*. In the present study, blood-fed mosquitoes were collected in the Everglades in 2016, 2017, 2021, and 2022, and from an industrial site in Naples, FL in 2017. Blood meals were identified to host species by PCR assays using mitochondrial cytochrome b gene. Blood meals were identified from *Anopheles crucians* complex and 11 mosquito species captured in the Florida Everglades and from 3 species collected from an industrial site. The largest numbers of blood-fed specimens were from *Culex nigripalpus*, *Culex erraticus*, *Culex cedecei*, and *Aedes taeniorhynchus*. *Cx. erraticus* fed on mammals, birds, and reptiles, particularly American alligator. This mosquito species could transmit WNV to American alligator in the wild. *Cx. nigripalpus* acquired blood meals primarily from birds and mammals and frequently fed on medium-sized mammals and white-tailed deer. Water and wading birds were the primary avian hosts for *Cx. nigripalpus* and *Cx. erraticus* in the Everglades. Wading birds are susceptible to WNV and could serve as reservoir hosts. *Cx. cedecei* fed on five species of rodents, particularly black and hispid cotton rats. EVEV and three different species of *Orthobunyavirus* have been isolated from the hispid cotton rat and *Cx. cedecei* in the Everglades. *Cx. cedecei* is likely acquiring and transmitting these viruses among hispid cotton rats and other rodents. The marsh rabbit was a frequent host for *An. crucians* complex. *An. crucians* complex, and other species could acquire Tensaw virus from rabbits. Our study contributes to a better understanding of the host and viral associations of mosquito species in southwestern Florida.

Zhang, M., Wang, J., Li, C., Wu, S., Liu, W., Zhou, C. and Ma, L. (2024). Cathelicidin AS-12W derived from the *Alligator sinensis* and its antimicrobial activity against drug-resistant gram-negative bacteria *in vitro* and *in vivo*. *Probiotics & Antimicrobial Proteins* (<https://doi.org/10.1007/s12602-024-10250-2>).

**Abstract:** Antimicrobial peptides (AMPs) have the potential to treat multidrug-resistant bacterial infections. Cathelicidins are a class of cationic antimicrobial peptides that are found in nearly all vertebrates. Herein, we determined the mature peptide region of *Alligator sinensis* cathelicidin by comparing its cathelicidin peptide sequence with those of other reptiles and designed nine peptide mutants based on the *Alligator sinensis* cathelicidin mature peptide. According to the antibacterial activity and cytotoxicity screening, the peptide AS-12W demonstrated broad-spectrum antibacterial activity and exhibited low erythrocyte hemolytic activity. In particular, AS-12W exhibited strong antibacterial activity and rapid bactericidal activity against carbapenem-resistant *Pseudomonas aeruginosa* *in vitro*. Additionally, AS-12W effectively removed carbapenem-resistant *P. aeruginosa* from blood and organs *in vivo*, leading to improved survival rates in septic mice. Furthermore, AS-12W exhibited good stability and tolerance to harsh conditions such as high heat, high salt, strong acid, and strong alkali, and it also displayed high stability toward trypsin and simulated gastric fluid (SGF). Moreover, AS-12W showed significant anti-inflammatory effects *in vitro* by inhibiting the production of proinflammatory factors induced by lipopolysaccharide (LPS). Due to its antibacterial mechanism against *Escherichia coli*, we found that this peptide could neutralize the negative charge on the surface of the bacteria and disrupt the integrity of the bacterial cell membrane. In addition, AS-12W has the ability to bind to the genomic DNA of bacteria and stimulate the production of reactive oxygen species (ROS) within bacteria, which is believed to be the reason for the good antibacterial activity of AS-12W. These results demonstrated that AS-12W exhibits remarkable antibacterial activity, particularly against carbapenem-resistant *P. aeruginosa*. Therefore, it is a potential candidate for antibacterial drug development.

Wu, D., Gu, J. and Yu, J. (2024). Influence of ecological restoration initiatives on emotional bonds between indigenous peoples and the Chinese alligator. *Frontiers in Environmental Science* 12 (<https://doi.org/10.3389/fenvs.2024.1395860>).

**Abstract:** As ecological restoration initiatives continue to revitalize degraded environments in the nature reserves, the dynamics of Indigenous people's emotional relationships with wildlife undergo significant shifts. Drawing upon the theoretical framework of emotion sociology, this research explored the intricate social mechanisms shaping Indigenous emotions toward wildlife. This research used a questionnaire survey. Based on a 10% sampling proportion, this research used the Kish selection method to draw a random sample of 361 households from the Chinese Alligator Reserve. It found that the main effect of the family population outflow (Coeff= -32.62), traditional cultural loss (Coeff= -2.51), pop culture familiarity (Coeff= 1.60) on Indigenous-wildlife emotion was significant. Meanwhile, the moderating effect of income is also clearly significant. This reveals the mechanisms by which ecological restoration initiatives create Indigenous and wildlife emotional ties are social support, cultural shaping, and income stratification. These findings underscore the importance of considering social effects in conservation efforts to foster sustainable relationships between Indigenous communities and wildlife in the nature reserves.

Erhan, S. (2024). The dangers we live with: Manmade dangers have risks but many possible solutions. *Tribology & Lubrication Technology* 80(4): 8.

**Abstract:** The article focuses on the dangers associated with driving, contrasting natural hazards like snakes and alligators with manmade risks such as traffic accidents. Topics discussed include the need for

increased alertness while driving, adherence to traffic rules, and the importance of practicing safety measures such as the Safety Training Observation Program (STOP).

Stannard, C.R., Lansdell, L. and Lindrew, S. (2024). Application of experimental patternmaking to increase utilisation and creative potential of American alligator leather. *International Journal of Fashion Design, Technology and Education* (<https://doi.org/10.1080/17543266.2024.2329177>).

**Abstract:** Today, there is a surplus of American alligator hides in the market (Fannin, Penn and Stannard 2021). Finding new uses for alligator leather is critical. However, alligator is challenging to use in apparel products. The irregular shape of the hide can make it difficult to cut items and garments require numerous skins (Belleau, Marquette and Summers 2004). Previously, Belleau *et al.* (2004) reported best practices for utilising alligator leather in apparel. This investigation was almost 20 years ago and did not use experimental patternmaking methods. The purpose of the present research was to apply experimental patternmaking methods to determine the best approach for utilising more of each alligator hide and maximising the creative potential of alligator leather. To investigate, a design team completed five designs. Each design employed a different experimental patternmaking method with alligator leather. Key requirements for designing with alligator were considered and combined by the design team.

Hernán Mateus-Vargas, R., Arias-Pérez, V., Sandoval-Hernández, I., Hammerl, J.A. and Barquero-Calvo, E. (2024). American crocodiles (*Crocodylus acutus*: Reptilia: Crocodylidae) visiting the facilities of a freshwater aquaculture of the Northern Pacific region, Costa Rica, carry tetracycline-resistant *Escherichia coli*. *Frontiers in Veterinary Science* ([doi: 10.3389/fvets.2024.1374677](https://doi.org/10.3389/fvets.2024.1374677)).

**Abstract:** Apex predators are exposed to antimicrobial compounds and resistant microbes, which accumulate at different trophic levels of the related ecosystems. The study aimed to characterize the presence and the antimicrobial resistance patterns of fecal *Escherichia coli* isolated from cloacal swab samples obtained from wild-living American crocodiles (*Crocodylus acutus*) (n= 53). Sampling was conducted within the distinctive context of a freshwater-intensive aquaculture farm in Costa Rica, where incoming crocodiles are temporarily held in captivity before release. Phenotypic antimicrobial susceptibility profiles were determined in all isolates, while resistant isolates were subjected to whole-genome sequencing and bioinformatics analyses. In total, 24 samples contained tetracycline-resistant *E. coli* (45.3%). Isolates carried either tet(A), tet(B), or tet(C) genes. Furthermore, genes conferring resistance to  $\beta$ -lactams, aminoglycosides, fosfomycin, sulfonamides, phenicol, quinolones, trimethoprim, and colistin were detected in single isolates, with seven of them carrying these genes on plasmids. Genome sequencing further revealed that sequence types, prevalence of antibiotic resistance carriage, and antibiotic resistance profiles differed between the individuals liberated within the next 24 h after their capture in the ponds and those liberated from enclosures after longer abodes. The overall presence of tetracycline-resistant *E. coli*, coupled with potential interactions with various anthropogenic factors before arriving at the facilities, hinders clear conclusions on the sources of antimicrobial resistance for the studied individuals. These aspects hold significant implications for both the aquaculture farm's biosecurity and the planning of environmental monitoring programs using such specimens. Considering human-crocodile conflicts from the One Health perspective, the occurrence of antimicrobial resistance underscores the importance of systematical surveillance of antibiotic resistance development in American crocodiles.

Scheelings, T.F., Koehler, A.V. and Gasser, R.B. (2024). New records of *Hepatozoon* and *Oswaldofilaria* from saltwater

crocodiles (*Crocodylus porosus*) in Australia. International Journal for Parasitology: Parasites and Wildlife (doi: 10.1016/j.ijppaw.2024.100926).

**Abstract:** Diseases affecting wild Australian saltwater crocodiles (*Crocodylus porosus*) are rarely reported due to the difficulty in capturing animals and obtaining samples. In this investigation, we identified two haemoparasites (*Hepatozoon* and a filarial nematode) in saltwater crocodiles in Darwin, Australia. Light microscopic examination identified *Hepatozoon* in 7/7 (100%) wild crocodiles and in 2/20 (10%) of captive ones. When genomic DNAs from these same samples were further investigated using polymerase chain reaction (PCR)-based sequencing, we detected *Hepatozoon* in all 27 blood samples. Using both microscopy and PCR-based sequencing, we detected a filarial worm (proposed to be *Oswaldofilaria*) in one of 20 captive crocodiles. The sequence data were compared with sequence data available in public databases, and phylogenetic analyses indicated that the operational taxonomic units of *Hepatozoon* and *Oswaldofilaria* discovered here in these crocodiles are likely new species. This study is the first to use molecular tools to explore haemoparasites in Australian saltwater crocodiles and highlights the importance of health investigations in poorly studied vertebrate hosts.

Guidry, A.R. and Elsey, R.M. (2024). Common Gallinule activity on unattended American alligator nest. Journal of Louisiana Ornithology 11: 10-12.

Small, A., Niemeyer, D. and Hewitt, L. (2023). Evaluation of a commercial electrical stunning method for farmed grower saltwater crocodiles (*Crocodylus porosus*) using non-invasive EEG measurements. Animal Welfare 32: e49.

**Abstract:** The aim of this study was to assess welfare outcomes of electrical stunning as a means of restraint in farmed grower saltwater crocodiles (*Crocodylus porosus*). Physical handling of a stunned, unconscious crocodile is far safer for the operator than handling a fully conscious animal. Electroencephalogram (EEG) was recorded before and after the application of electrical stunning at 50 Hz or 400 Hz using an electrical stunner applied to the cranial plate (Position 1: P1-50 Hz; n= 31, P1-400 Hz; n= 29) or immediately behind the skull (Position 2: P2-50 Hz; n= 29; P2-400 Hz; n= 30). For all electrical stuns, percentage total EEG power in a 10-s epoch decreased in the alpha and beta frequency bands; and increased in the delta and lower frequencies bands. All electrical stuns resulted in increased strength of signal, based on the quadratic mean EEG power in all frequency bands of the EEG. Greatest change in power occurred in the delta frequency band, with P1-50 Hz. This was greater than with P2-50 Hz; while decibel change using 400 Hz at either position was intermediate and not significantly different from either. Application of either electrical stunner at position 1 resulted in seizure-like activity and activation in low frequencies, but at position 2 this was not consistent across all animals. The ability of the electrical stunning equipment to consistently induce recoverable unconsciousness could be ranked in decreasing order as: P1-50 Hz > P1-400 Hz = P2-50 Hz > P2-400 Hz. Based on behavioural observations, all animals in the study appeared to stunned however evaluation of duration of EEG changes indicates that use of the electrical stunning equipment at 50 Hz would allow some margin for inaccuracies in tong placement, while achieving a consistently reliable stun.

Balaguera-Reina, S.A., Mason, B.M., Brandt, L.A., Hernandez, N.D., Daykin, B.L., McCaffrey, K.R., Godfrey, S.T. and Mazzotti, F.J. (2024). Ecological implications of allometric relationships in American alligators (*Alligator mississippiensis*). Scientific Reports 14(1): 6140.

**Abstract:** Morphometric allometry, the effect of size on

morphological variation, has been of great interest for evolutionary biologist and is currently used in fields such as wildlife ecology to inform management and conservation. We assessed American alligator (*Alligator mississippiensis*) morphological static allometry across the Greater Everglades ecosystem in South Florida, United States using a robust dataset (~22 years) and investigated effects of sex, habitat, and sampling area on morphological relationships. Regression models showed very strong evidence of a linear relationship between variables explaining equal to or above 92% of the variation in the data. Most trait-size relationships (8 out of 11 assessed) showed hyperallometry (positive allometry) with slope deviations from isometry between 0.1 and 0.2 units while the other three relationships were isometric. Sampling area, type of habitat, and in a lesser extent sex influenced allometric coefficients (slope and intercept) across several relationships, likely as result of differing landscapes and ecosystem dynamic alterations and sexual dimorphism. We discuss our findings in terms of the biology of the species as well as the usefulness of our results in the context of ecosystem restoration and conservation of the species. Finally, we provide recommendations when using trait-length relationships to infer population nutritional-health condition and demographics.

Chaiwattanarungruengpaisan, S., Thongdee, M., Arya, N., Paungpin, W., Sirimanpong, W. and Sariya, L. (2024). Diversity and genetic characterization of *Chlamydia* isolated from Siamese crocodiles (*Crocodylus siamensis*). Acta Tropica (doi: 10.1016/j.actatropica.2024.107183).

**Abstract:** Chlamydiosis, an infection caused by several *Chlamydia* species, has been reported in Nile, saltwater, and Siamese crocodiles. Despite its widespread reports in various countries, including Thailand, genetic information on *Chlamydia* species remains limited. This study presents a whole-genome-based characterization of Siamese crocodile-isolated *Chlamydia*. The results showed that Siamese crocodile *Chlamydia* contained a single circular chromosome with a size of 1.22-1.23 Mbp and a plasmid with a size of 7.7-8.0 kbp. A plasmid containing eight coding sequences (CDSs) was grouped in a  $\beta$  lineage. A chromosome sequence had approximately 1018-1031 CDSs. Chlamydial factors involving virulence were documented in terms of the presence of cytotoxins and several virulence factors in the chromosomes of Siamese crocodile *Chlamydia*. The analysis of antimicrobial resistance genes in the *Chlamydia* genome revealed that the most common resistance genes were associated with aminoglycosides, fluoroquinolones, macrolides, tetracyclines, and cephalosporins, with loose matching (identities between 21.12% and 74.65%). Phylogenetic analyses, encompassing the assessments of both whole proteome and nine taxonomic markers, revealed that Siamese crocodile *Chlamydia* was separated into three lineages (lineages I-III) with high bootstrapping statistic support. Interestingly, isolate 12-01 differed genetically from the others, suggesting that it is a new member of *Chlamydia*. The study findings indicate that Siamese crocodiles are susceptible hosts to *Chlamydia*, involving more than one species. This study is the first employing the highest number of whole-genome data on Siamese crocodile *Chlamydia* and provides better insights into pathogen genetics.

Bors, M.S., Gowri Shankar, P. and Gruszczyńska, J. (2024). Current state of Mugger populations. Animals (Basel) 14(5) (doi: 10.3390/ani14050691).

**Abstract:** The Mugger (*Crocodylus palustris*) is a medium-sized crocodilian inhabiting South Asia. As a result of intensive hunting, its range declined drastically up till the 1970s. Currently, the world mugger population is fragmented and threatened mainly by habitat loss and the consequences of human-crocodile conflict, being classified as Vulnerable by the IUCN. The goal of this paper is to comprehensively determine the Mugger's current range, and assess risks in notable habitats of the species across its range. To determine the range and notable habitats, extensive literature covering surveys,



monitoring, population studies and reports of human-crocodile conflict was examined. Habitat suitability and risk assessment were performed by evaluating selected habitats using eight factors: the legal status of the area, elevation, surface water availability, water quality, salinity, availability of nesting and basking sites, interaction with humans and interspecific competition. Based on our findings, the chances of the mugger's survival varies greatly across its range and the threats they face are complex and often site-specific. Defining these threats is the first step for determining suitable risk mitigation efforts, some of which are explored in this review.

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Yang, L. Ling, J., Lu, L., Zang, D., Zhu, Y., Zhang, S., Zhou, Y., Yi, P., Li, E., Pan, T. and Wu, X. (2024). Identification of suitable habitats and priority conservation areas under climate change scenarios for the Chinese alligator (*Alligator sinensis*). *Ecology and Evolution* 14: e11477.

**Abstract:** Amphibians and reptiles, especially the critically endangered Chinese alligators, are vulnerable to climate change. Historically, the decline in suitable habitats and fragmentation has restricted the distribution of Chinese alligators to a small area in southeast Anhui Province in China. However, the effects of climate change on range-restricted Chinese alligator habitats are largely unknown. We aimed to predict current and future (2050s and 2070s) Chinese alligator distribution and identify priority conservation areas under climate change. We employed species distribution models, barycenter migration analyses, and the Marxian model to assess current and future Chinese alligator distribution and identify priority conservation areas under climate change. The results showed that the lowest temperature and rainfall seasonality in the coldest month were the two most important factors affecting the distribution of Chinese alligators. Future predictions indicate a reduction (3.39%-98.41%) in suitable habitats and a westward shift in their distribution. Further, the study emphasizes that suitable habitats for Chinese alligators are threatened by climate change. Despite the impact of the Anhui Chinese Alligator National Nature Reserve, protection gaps persist, with 78.27% of the area lacking priority protected area. Our study provides crucial data for Chinese alligator adaptation to climate change and underscores the need for improved conservation strategies. Future research should refine conservation efforts, consider individual plasticity, and address identified limitations to enhance the resilience of Chinese alligator populations in the face of ongoing climate change.

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Lima Dos Santos, R., Freire Mariz Jr, C., Braga Mascarenhas-Júnior, P., Sá Leitão Barboza, R., Maranhão Dos Santos, E., de Sousa Correia, J.M. and Martins de Carvalho, P.S. (2024). Nondestructive evaluation of metal bioaccumulation and biochemical biomarkers in blood of Broad-snouted caiman (*Caiman latirostris*) from northeastern Brasil. *Environmental Toxicology and Chemistry* 43(4): 878-895.

**Abstract:** Studies on the bioaccumulation and toxicity of contaminants in Crocodylians are scarce. We evaluated alterations in concentrations of the nondestructive biomarkers butyrylcholinesterase (BChE), glutathione-S-transferase (GST), superoxide dismutase (SOD), and reduced glutathione (GSH), together with bioaccumulation of the metals iron (Fe), copper (Cu), zinc (Zn), manganese (Mn), chromium (Cr), aluminium (Al), and lead (Pb) in Caiman latirostris captured in Tapacurá Reservoir (TR; São Lourenço da Mata, Pernambuco, Brasil), in urbanized areas of Pernambuco State (UA; Brasil) and from the AME Brasil caiman farm (AF; Marechal Deodoro, Alagoas, Brasil); the latter was used as a potential reference with low levels of contamination. For metal analysis, 500 µL of blood was digested in 65% HNO<sub>3</sub> and 30% H<sub>2</sub>O<sub>2</sub>. The samples were analyzed by inductively coupled plasma-optical emission spectrometry. For analysis of biomarkers, an aliquot of blood was centrifuged to obtain plasma in which biochemical assays were performed. Blood concentrations of metals analyzed in animals from AF were lower compared with TR and

UA, confirming that animals from the caiman farm could be used as references with low levels of contamination. Iron, Cu, Mn, Al, and Pb exceeded toxic levels for other vertebrates in animals from TR and UA. Butyrylcholinesterase activity showed significant reduction in adults from UA and TR compared with AF. An increase in the activity of GST and GSH, in adults of TR and UA in relation to AF, was verified. Superoxide dismutase activity showed a significant reduction in adults of TR in relation to AF, and the concentrations of Cu and Mn were negatively correlated with SOD activity. Animals from UA and TR showed greater concentrations of the analyzed metals compared with reference animals, and changes in biomarkers were seen, confirming the potential of these nondestructive chemical and biological parameters in blood of *C. latirostris* for biomonitoring of pollution.

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Zhang, Q.Q., Tang, J., Wu, Y.F., Qian, C.Y., Qin, S., Cai, Z.H., Wang, H. and Xiao, H.M. (2024). Gelation of crocodile myofibrillar protein -  $\kappa$ -carrageenan mixtures in two low-NaCl solution. *Food Chemistry* (doi: 10.1016/j.foodchem.2024.138753).

**Abstract:** Crocodile meat is a novel reptile meat source, but its processing method is rare. This study investigated the effect of  $\kappa$ -carrageenan addition and partial substitution of NaCl on the gel properties of crocodile myofibrillar protein (CMP). Result showed that CMP formed gel when temperature above 60°C. The water-holding capacity, gel strength, denaturation degree, sulfhydryl content covalent bond and hydrophobic bond of gel in KCl solution were significantly higher than those in CaCl<sub>2</sub> solution (P<0.05). K<sup>+</sup> induced CMP to form a tight network structure with uniform small pores though covalent and hydrophobic bonds, but the gel properties were reduced by  $\kappa$ -carrageenan. In CaCl<sub>2</sub> solution,  $\kappa$ -carrageenan improved the gel structure by filling the protein network through hydrogen bonding. Therefore, it can be concluded that KCl is better than CaCl<sub>2</sub> in the manufacturing of low-sodium crocodile foods. Moreover,  $\kappa$ -carrageenan was only beneficial to gel quality in CaCl<sub>2</sub> solution.

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Sarani, S., Pirzadeh, B. and Zamani, Y. (2024). Investigation of the impacts of climate change on the environment and water requirements of Marsh crocodiles (*Crocodylus palustris*). *Journal of Natural Environmental Hazards* (10.22111/jneh.2024.47372.2008).

**Abstract:** There are very valuable habitats and ecological areas in Iran. One of these areas is Sistan and Baluchestan province, which is known as the habitat of the swamp crocodile, the only representative species of the order of crocodiles in Iran. Preservation of this valuable species and its environment in the conditions of global warming, consecutive droughts, and future climate changes requires planning and management of water resources. To achieve this goal, WEAP software was selected to simulate and model water resources in the Gwando protected area, and after simulating the geometry of the area, by defining eight scenarios, different management policies were investigated to optimize the use of water resources under climate change conditions. In this research, exponential micro-scale and production of meteorological data of the region under the influence of climate change in the future was done with the help of LARS-WG software. The results showed that with the continuation of the current conditions in the studied time horizon (20 years), there is an unmet demand of 27.75 million cubic meters, which population growth and the continuation of geopolitical policies for the development of trade and industry will increase the intensity of tension and water demand in the region. Even the scenario of saving and managing water demand, although with a 10% reduction in consumption, has an effect on reducing the amount of unmet demand, but it is not enough.

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Hor, S., Dim, K., Kang, S., Kang, K., Theng, K. and Ith, M. (2024). Growth performance of crocodile fed with chicken intestine and trash fish at smallholder farm in Siem Reap Province, Cambodia.

**Abstract:** The experiment was conducted at the smallholder crocodile farm at Pouk district, Siem reap province, and lasted 12 months, commenced from 1 January to 31 December 2023. The CRBD (Completely Randomized Block Design), was used in 3 treatments, such as T1 (fed chicken intestine only), T2 (fed chicken intestine + trash fish) and T3 (fed trash fish only), with 4 replications in each treatment. The block was set by gender of crocodile, male and female. The 36 of local breed crocodiles 4 months old were allocated into each replication randomly. The result found that the length of crocodile gradually increased in the first semester, then it greatly increased from or for second semester for all treatments. In addition, the final body length of crocodile was significant different among treatments ( $p < 0.001$ ), the treatment of T2 (fed chicken intestine + trash fish) had the longest one. Body length was also affected by gender, and male crocodile had longer body length ( $p < 0.001$ ). However, there were no significant differences for the interaction between types of feed with gender ( $p > 0.05$ ) (Table 1). The body weight of crocodile had gradually increased in the first semester, then it greatly increased from or for second semester for all treatments, while the final body weight of crocodile was also significant different among treatments ( $p < 0.001$ ) and the gender of crocodile ( $p < 0.001$ ). The average ADG (Daily Weight Gain) was significant different among treatments ( $p < 0.001$ ). Treatment of T2 (fed chicken intestine + trash fish) had highest ADG, 11.05 g, followed by T3 (fed trash fish only), while the T1 had the lowest one. The gender of crocodile affected the ADG of crocodile, and male crocodile had higher ADG than female crocodile ( $p < 0.001$ ). However, there were no significant differences for the interaction between type of feed with gender ( $p > 0.05$ ). Feed intake was calculated based on amount of feed offer and measured in fresh basis. The amount of intake feed in all treatments was the same. FCR (Feed Conversion Ratio) was significant different among treatments ( $p < 0.001$ ) and also gender of crocodile ( $p < 0.001$ ). However, there were no significant differences for the interaction between types of feed with gender ( $p > 0.05$ ). In conclusion, the uses of trash fish and chicken intestine are an alternative feed source for crocodile to result in higher growth performance of crocodile.

Forêt, T., Aubier, P., Jouve, S. and Cubo, J. (2024). Biotic and abiotic factors and the phylogenetic structure of extinction in the evolution of Tethysuchia. *Paleobiology* (doi: <https://doi.org/10.1017/pab.2024.5>).

**Abstract:** Crocodylomorpha is a large and diverse clade with a long evolutionary history now restricted to modern crocodilians. Tethysuchia is a less-inclusive clade of semi-amphibious taxa that crossed two biological crises: the second Oceanic Anoxic Event (OAE 2) and the Cretaceous/Paleogene (K/Pg) crisis. Numerous studies have sought to find the driving factors explaining crocodylomorph evolution, producing contradictory conclusions. Studies of included groups may be useful. Here, we study factors driving tethysuchian evolution using phylogenetically informed statistical analyses. First, we tested the phylogenetic structure of tethysuchian extinction at the OAE 2 and K/Pg crises. We then used phylogenetic comparative methods to test the influence of intrinsic (body size, snout proportion) and extrinsic (temperature, paleolatitude) factors on the evolution of tethysuchian diversity at the OAE 2 and the K/Pg crises. Finally, we tested whether temperature influenced the evolution of body size. We conclude that (1) extinction was not random in regard to phylogeny for Tethysuchia at the OAE 2 and K/Pg crises; (2) while an important tethysuchian turnover follows OAE 2, the K/Pg crisis was followed by an explosion in diversity of tethysuchians, probably linked to the colonization of emptied ecological niches; (3) tethysuchians lived in warmer environments after the OAE 2 crisis, possibly because of both global warming and latitudinal distribution shifts; (4) there is a significant change of snout proportion after the OAE 2 and the K/Pg crises, likely caused by niche partitioning; and (5) there is a positive correlation between body size and temperature, possibly because of a longer growth season.

Cruz, J.A., Wooldrich-Piña, G.A., Basanta, M.D., García-Castillo, M.G. and Parra-Olea, G. (2024). Reptiles as paleoenvironmental proxies and their association with the climate. Pp. 273-287 in *Past Environments of Mexico*, ed. by R. Guerrero-Arenas and E. Jiménez-Hidalgo. Springer: Cham.

**Abstract:** Reptiles are animals that depend on external environmental conditions to regulate their body temperature. The temperature is a key factor for the embryonic development in viviparous reptiles and is an important element in biological and ecological processes, such as metabolism, growth, social interactions, reproduction, abundance, and distribution. In this respect, reptiles have relatively limited ranges and preferences of temperatures that they can tolerate, and these ranges differ in species or families of reptiles; then, reptiles should be useful for the determination of past climates. The relationship between climate and reptiles had been used in these organisms as paleothermometers; for example, the tropical affinity in the distribution of crocodilians allow us to infer the climate when we found fossil crocodilians in high latitudes with respect to current distribution range. The presence of giant snakes and lizards during the Paleogene has allowed us to infer the climate with the relationship between the size and temperature in reptiles. In Mexico, the quantitative paleoenvironmental reconstructions with reptiles is very recent; the works carried out include the use of fossil communities, biogeographic, and climatic niche data to infer the paleotemperatures and paleoprecipitation in different Pleistocene sites in Mexico.

Hilevski, S., Cordero, T., Moleón, M.S., Cabaña, E., Belotti, M. and Siroski, P. (2024). Serum biochemical profile, intestinal and liver histomorphometry of captive Broad-snouted caiman (*Caiman latirostris*) fed with a diet enriched with soybean (*Glycine max*). Available at SSRN: <https://ssrn.com/abstract=4848229> or <http://dx.doi.org/10.2139/ssrn.4848229>.

**Abstract:** The impact of plant-based diets on carnivores is unclear. Serum profiles and histomorphometry provide valuable insights into their nutritional and physiological status. This study aims to elucidate the impact of three levels of soybean meal substitution combined chicken by-product minced on the growth and health of broad-snouted caiman (*Caiman latirostris*). The research assesses the effects of diets supplemented with soybean meal on the blood biochemical profile, intestinal histomorphometry, and hepatic parameters of *C. latirostris*, providing essential information for understanding on the implications of dietary changes in this species. Forty-eight 6-month-old broad-snouted caimans were assigned to three dietary groups (0%, 25%, 40% soybean meal). Over a period of 90 days, data on growth, food consumption, serum biochemical analysis, intestinal and hepatic morphometry were recorded. Results indicated that diets with higher soybean meal content did not significantly affect growth, food consumption, or serum protein profiles. However, changes in intestinal morphology were observed, with longer and wider villi in the animals feed with diets with soybean meal, indicating a gradual adaptation to new feeding diets. The presence of soybean meal reduced hepatic lipid accumulation without affecting macronutrient digestion and absorption, considered beneficial for the caiman's health. This study provides valuable insights into the inclusion of soybean meal in the diet of *C. latirostris* and its effects on the intestines, liver, and physiology. It also highlights the importance of considering nutritional management as a key tool in improving the well-being and health of crocodilians in captivity.

Kidd-Weaver, A.D., Rainwater, T.R., Hoog, M.E. and Bodinof Jachowski, C.M. (2024). Investigating the impact of human disturbance on predator behaviour in human-dominated landscapes. *Animal Behaviour* 211: 13-24.

**Abstract:** Human-wildlife interactions are increasing globally due to human population growth and development. Wildlife often develop an increased tolerance of humans through the learning processes

of habituation, but habituation of large predators can increase risks to humans. Aversive conditioning is a management strategy that operationalizes learning to reduce wildlife tolerance of humans and thereby improve human safety. However, developed landscapes may select for wildlife phenotypes that are resistant to learning via aversive conditioning. We investigated American alligators', *Alligator mississippiensis*, response to capture and release (an assumed aversive experience) in coastal resort communities as a model system for understanding wildlife learning in human-dominated landscapes. Our objectives were to investigate whether the degree of human disturbance in the landscape was associated with baseline alligator tolerance of humans or mediated alligators' learning ability. We quantified tolerance using flight initiation trials and estimated learning ability as the response to capture and release using a 'before-after control impact' experimental design. Baseline alligator tolerance did not vary with disturbance, nor did the degree of disturbance impact alligator learning. However, alligators in areas where capture and release occurred were 1.5 times more likely to flee from an approaching human after treatment relative to before. Alligators in control units exhibited similar tolerance to humans over time. Alligator tolerance was also influenced by ambient weather, with alligators least tolerant of humans in cool and cloudy conditions and most tolerant in warm conditions, likely reflecting physiological constraints of ectothermy. While human-dominated landscapes may promote high tolerance of humans through habituation, our findings indicate that high tolerance does not preclude future learning by crocodilians and collectively lend credibility to the use of repeated capture and release as a potential form of aversive conditioning for crocodilians.

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Bangma, J., Pu, S., Robuck, A., Boettger, J., Guillette, T., McCord, J., Rock, K.D., Sobus, J., Jackson, T.W. and Belcher, S.M. (2024). Biomonitoring of emerging perfluoroethers in wildlife and pets in North Carolina. Available at SSRN: <https://ssrn.com/abstract=4844363> or <http://dx.doi.org/10.2139/ssrn.4844363>.

**Abstract:** The recent application of non-targeted analysis (NTA) techniques in environmental monitoring has revealed numerous novel fluorinated species in surface water, wildlife, and humans in the Cape Fear River (CFR) region of North Carolina. In this study, we have re-examined archived alligator, striped bass, horse, and dog serum as well as various archived seabird tissue data from previously reported exposure studies in the region in order to extend the panel of detected novel PFAS. In this study, the compounds PFO6, PFO7, PFO8, and Nafion byproduct 6 (NBP6) were detected for the first time in environmental tissues even though not previously detected in the CFR. Analytical standards were available for PFO6 and NBP6, and therefore, were quantitated in investigated tissues. PFO7 and PFO8 had no available standards and were semi-quantitated using NTA techniques. Of note, PFO6, PFO7, and PFO8 were observed in alligator, bass, and seabird but not horse and dog. PFO6 was detected at the highest frequency in all investigated tissues with PFO7 and PFO8 detected at lower frequencies. NBP6 was observed in seabird tissues but was not successfully detected above quality control metrics in other species. Seabird tissue to blood ratios suggests PFO6 is highest in the heart kidney and liver and lowest in the brain. Overall, additional studies are needed to fully understand the potential impact of these additional novel PFAS on both wildlife and humans in the CFR region.

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LaBarge, T.W. and Njau, J.K. (2024). Taxonomic reappraisal of *Nihilichnus* from taphonomic perspectives of crocodile predatory ecology. *Ichnos* (doi: 10.1080/10420940.2024.2353199).

**Abstract:** The ichnogenus *Nihilichnus* has been broadly applied to penetrative feeding traces (bite marks) generated by vertebrates. The type ichnospecies *Nihilichnus nihilicus* encompasses all pit and puncture traces on vertebrate bone. This definition belies the diversity of pit and puncture morphologies found in the palaeontological and archaeological record and has led to inconsistency in the

application and interpretation of these trace fossils. We resolve this ambiguity by splitting previously included morphologies that are too morphologically disparate to include within one ichnospecies. Using a sample of fossil, modern, and experimentally obtained crocodile modified bones, we describe three new ichnospecies under this ichnogenus: rounded pits *N. clavus* n. isp., bisected pits *N. sicarius* n. isp., and bisected punctures *N. hastarius* n. isp.; all of which we contend are morphologically distinct. Using these new ichnospecies, we provide a review, and reclassification when appropriate, of feeding traces previously published under *Nihilichnus*. We find that *N. mortalis*, lacking any official documentation, is nomen nudum and thus taxonomically unavailable. This article highlights how the usage of more specific ichnotaxonomic descriptions improves the utility of praedichnia in making palaeoecological inferences.

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Wang, J., Ji, Y. and Meng, X. (2024). Communities beyond geographical limitation: The network characteristics of international wildlife trade under the pandemic. *Global Ecology and Conservation* 53 (<https://doi.org/10.1016/j.gecco.2024.e03032>).

**Abstract:** The international wildlife trade, contributing billions of dollars to global economies and encompassing thousands of species, has increased due to rising demands for wildlife products. Revealing the key participants and trade characteristics across taxa is imperative for sustaining wildlife resources and conservation efforts. To provide a basis for informed wildlife management and trade supervision, we investigated the global wildlife trade's fundamental characteristics and spatial patterns by analyzing transaction records reported to The Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) from 2020 to 2022. During this period, the essential demands for wildlife were highlighted due to stricter trade regulations and higher trade costs in response to the suspected wildlife origin of the pandemic. Our analysis highlights the formation of trade communities that are tightly interconnected by strong trade relations in wildlife trade networks, transcending geographical limitations. Unlike the division of the continents, geographical proximity alone does not necessarily contribute to the formation of these trade communities. Germany emerges as the leading importer based on trade frequency, while the Netherlands leads in exports. The main driving forces behind wildlife trades include commercial use (74.98%), personal use (3.80%), and hunting trophies (3.19%). Apart from 44.90% of flora trades, Reptilia was the primary traded taxa (21.08%), involving 196 engaged countries/territories with the most mutual connections (27.21%) and an average of 12.51 shipments to 11.33 nodes. Aves (9.70%), Mammalia (9.44%), and Anthozoa (7.62%) followed. Notably, certain European and Asian countries/territories dominate the import or export of most trades, exhibiting distinct variations across taxa. The United Arab Emirates led the Aves trade, accounting for 15.96% of global Aves transactions during this period. Similarly, Italy led the Reptilia trades (21.28%), South Africa led the Mammalia trades (18.72%), and Indonesia led the trades in Insecta (56.84%), Hydrozoa (66.96%), and Anthozoa (56.12%). Our findings underscore the traded species facing overexploited and the countries most involved, thereby informing proactive monitoring and policy-making for sustainable wildlife conservation and management.

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Roussel, D., Roussel, N., Voituron, Y. and Rey, B. (2024). Liver mitochondrial coupling efficiency and its relationship to oxidative capacity and adenine nucleotide translocase content: A comparative study among crocodiles, birds and mammals. *Mitochondrion* 78 (<https://doi.org/10.1016/j.mito.2024.101909>).

**Abstract:** The primary objective of this study was to assess whether adenine nucleotide translocase (ANT) content could be associated with phylogenetic disparities in mitochondrial coupling efficiency, within liver mitochondria obtained from rats, crocodiles, and ducklings. Our measurements included mitochondrial membrane conductance, ANT content, and oxidative phosphorylation fluxes at various steady-state rates. We observed significant variations in liver



mitochondrial coupling efficiency across the three species. These variations correlated with interspecific differences in mitochondrial oxidative capacity and, to a lesser extent, the ANT content of liver mitochondria. These findings expand upon previous research by highlighting the pivotal role of oxidative capacity and ANT in modulating mitochondrial efficiency on an interspecific scale.

Desai, B., Bhowmik, T., Srinivasan, R., Whitaker, N. and Ghosal, R. (2024). Monitoring the stress physiology of free-ranging mugger crocodiles (*Crocodylus palustris*) across diverse habitats within Central Gujarat, India. *Conservation Physiology* 12 (10.1093/conphys/coae035)

**Abstract:** Animals face several challenges in their natural environment, and to cope with such conditions, they may exhibit contrasting physiological responses that directly affect their overall well-being and survival. In this study, we assessed physiological responses via faecal glucocorticoid metabolite (fGCM) measurements in free-ranging Mugger crocodiles inhabiting diverse habitats in Gujarat, India. We sampled Muggers within Charotar, a rural area (Zone A) with local people having high tolerance towards the presence of Muggers, and Vadodara, a region having both urban (Zone B) and rural (Zone C) areas with high levels of Human-Mugger Conflict (HMC). Further, Muggers in Vadodara live in water bodies that are mostly polluted due to sewage disposal from adjoining chemical industries. To measure fGCM (mean  $\pm$  SEM, ng/g dry faeces) levels in Muggers, scats were collected during both breeding (N= 107 scats) and non-breeding (N= 22 scats) seasons from all three zones. We used captive Muggers (a focal enclosure) to biologically validate (via capture and restraint) the selected fGCM assay (11-oxoetiocholanolone assay). We showed a significant ( $P<0.05$ ) 11-fold increase in fGCM levels between pre-capture ( $540.9 \pm 149.2$ , N= 11) and post-capture ( $6259.7 \pm 1150.5$ , N= 11) samples. The validated assay was applied to free-ranging Muggers during the breeding season, and Zone A showed significantly ( $P<0.05$ ) lower fGCM levels ( $542.03 \pm 71.3$ ) compared to Muggers of Zone B ( $1699.9 \pm 180.8$ ) and Zone C ( $1806.4 \pm 243.2$ ), both zones having high levels of HMC with polluted water bodies. A similar contrast in fGCM levels was also observed during the non-breeding season. Overall, the study demonstrated that fGCM levels in Muggers varied across habitats, and such variation could be due to a multitude of ecological factors that the species experience in their immediate local environment. Moreover, high fGCM levels in Muggers of Vadodara during both breeding and non-breeding seasons may indicate a condition of chronic stress, which could be maladaptive for the species.

Meredith, R.W., Milián-García, Y., Gatesy, J., Russello, M.A. and Amato, G. (2024). Draft assembly and annotation of the Cuban crocodile (*Crocodylus rhombifer*) genome. *BMC Genomic Data* 25: 53.

**Abstract:** Objectives: The new data provide an important genomic resource for the Critically Endangered Cuban crocodile (*Crocodylus rhombifer*). Cuban crocodiles are restricted to the Zapata Swamp in southern Matanzas Province, Cuba, and readily hybridize with the widespread American crocodile (*Crocodylus acutus*) in areas of sympatry. The reported de novo assembly will contribute to studies of crocodylian evolutionary history and provide a resource for informing Cuban crocodile conservation. Data description: The final 2.2 Gb draft genome for *C. rhombifer* consists of 41,387 scaffolds (contigs: N50= 104.67 Kb; scaffold: N50=18.55 Kb). Benchmarking Universal Single-Copy Orthologs (BUSCO) identified 92.3% of the 3354 genes in the vertebrata\_odb10 database. Approximately 42% of the genome (960Mbp) comprises repeat elements. We predicted 30,138 unique protein-coding sequences (17,737 unique genes) in the genome assembly. Functional annotation found the top Gene Ontology annotations for Biological Processes, Molecular Function, and Cellular Component were regulation, protein, and intracellular, respectively. This assembly will support future macroevolutionary,

conservation, and molecular studies of the Cuban crocodile.

Baez, J.C., Fuentes Tejada, L. and Torreblanca, D. (2024). Specific marine policies are needed to prevent the extinction of marine reptiles. *Frontiers in Marine Science* 11 (doi: 10.3389/fmars.2024.1416178).

Bob Mali, B., Owembabazi, L., Sente, C. and Okello, S. (2024). Morphometrics and carcass production of Nile crocodile (*Crocodylus niloticus*) under intensive production system. *African Journal of Agricultural* 20(6): 442-446.

**Abstract:** The aim of this study was to determine the carcass production and obtain linear models for the estimation of live weight of Nile crocodile (*Crocodylus niloticus*), reared under intensive system. Three-year-old crocodiles destined for slaughter were restrained, stunned and thereafter, the spinal cord severed instantly. The live weight of each crocodile was measured and the corresponding morphometric measurements were taken. The measurements included: body length, height at withers, heart girth, loin/inguinal girth, head width, head length, length of hind quarter and hindquarter width. Upon slaughter of the crocodiles, the carcass weight was measured and the dressing percentage was calculated. Independent sample T tests were used to determine significant differences between male and female morphometric measurements and production. Linear and multiple linear regressions were used to obtain models, for estimation of live weight of Nile crocodile. IBM® SPSS® statistics 24 was used for the analysis. The study revealed males were larger than females. With linear regression analysis, the highest accuracy of live weight prediction at 76% was achieved using heart girth. With multiple linear regressions, 85% accuracy in estimation of Nile crocodile live weight, under intensive system of production was achieved using all eight predictors.

Wang, J., Torres, I.M., Shang, M., Al-Armanazi, J., Dilawar, H., Hettiarachchi, D.U., Paladines-Parrales, A., Chambers, B., Pottle, K., Soman, M., Wise, A.L., Simora, R.M.C., Bruce, T.J., Su, B. and Dunham, R.A. (2024). Direct and pleiotropic effects of antimicrobial peptide transgene integration on reproductive, growth regulating, and non-coding loci in channel catfish (*Ictalurus punctatus*) *Agriculture Communications* 2(2) (<https://doi.org/10.1016/j.agrcom.2024.100044>).

**Abstract:** Antimicrobial peptides (AMPs) show promise in enhancing resistance against pathogens. Previously, we integrated two AMP genes, cathelicidin (*Cath*) from alligator (*Alligator mississippiensis* or *Alligator sinensis*) and cecropin (*Cec*) from moth (*Hyalophora cecropia*), into the channel catfish (*Ictalurus punctatus*) genome. This study examines the efficacy of exogenous AMP gene integration in improving bacterial resistance in transgenic channel catfish and assesses the direct and pleiotropic effects of gene replacement/knockout on survival and growth based on insertion site. Transgenic *Cath*- and *Cec*-expressing fish exhibited similar or higher survival rates ( $P>0.05$ ) compared to controls during the initial culture. Integration of the *Cec* transgene doubled the survival rate when challenged with *Edwardsiella ictaluri*, with knock-in (KI) of *Cath* further increasing bacterial resistance. Coupling *Cec* KI with *mstn* knockout (KO) increased survival 3-fold after *E. ictaluri* infection and growth by 50% at 4 months post-fertilization (*mpf*). However, random integration of *Cec* had a minimal effect on disease resistance and did not enhance growth. Random integration of *Cath* increased survival 2.5-fold and 4-fold against *E. ictaluri* and *Flavobacterium covaie*, respectively, without affecting growth. *Cath* KI at the *lh* locus increased survival 4-fold when challenged with *F. covaie* and reduced growth by 10% ( $P>0.05$ ) at 24 *mpf*, whereas *Cath* KI coupled with *mc4r* KO resulted in a 2.5-fold increase in survival following *F. covaie* infection compared with controls, and increased growth by 80% at 3 *mpf*. Simultaneous KI of *Cath* and *Cec*, along with KO of *mc4r* and *mstn*, increased survival 4-fold against *E. ictaluri*, while increasing growth by 50% at 3 *mpf*. Dual

insertion of AMP genes yielded the greatest resistance to disease. These direct and pleiotropic effects may increase comprehension and societal acceptance of genetic engineering in aquaculture.

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McAllister, C.T. (2024). Pentastomida: Endoparasitic arthropods. Chapter 59. Pp. 717-731 in *Concepts in Animal Parasitology*, ed. by S.L. Gardner and S.A. Gardner. Zea Books: Lincoln, Nebraska, USA.

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Overstreet, R.M. (2024). Summary of the Digenea (Subclass): Insights and lessons from a prominent parasitologist. Chapter 47. Pp. 491-531 in *Concepts in Animal Parasitology*, ed. by S.L. Gardner and S.A. Gardner. Zea Books: Lincoln, Nebraska, USA.

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Swanepoel, A.A., Truter, C., Viljoen, F.P., Myburgh, J.G. and Harvey, B.H. (2024). Temporal dynamics of plasma catecholamines, metabolic and immune markers, and corticosterone: DHEA ratio in farmed crocodiles before and after an acute stressor. Preprints.org (doi: 10.20944/preprints202406.0944.v1).

**Abstract:** Commercial crocodilian farms face significant economic and livestock losses attributed to stress, which may be linked to their adopted husbandry practices. The development of appropriate and modernized husbandry guidelines, particularly those focused on stress mitigation, is impeded by the limited understanding of the crocodilian stress response. Fifteen grower Nile crocodiles were subjected to simulated acute transport stress, with blood samples collected at various intervals post-stress. Plasma levels of corticosterone, dehydroepiandrosterone (DHEA), adrenaline, and noradrenaline were determined using high-performance liquid chromatography. Glucose and lactate were measured using portable meters, and the heterophil-to-lymphocyte ratio (HLR) was determined via differential leucocyte counts. Significant differences were elicited after the stressor, with acute fluctuations observed in the fast-acting catecholamines (adrenaline and noradrenaline) when compared to baseline. Downstream effects of these catecholamines and corticosterone appear to be associated with a persistent increase in plasma glucose and HLR. Lactate also showed acute fluctuations over time but returned to baseline by the final measurement. DHEA, used as a ratio with corticosterone, showed fluctuations over time with an inverted release pattern to the catecholamines. The study highlights the temporal dynamics of physiological markers under acute stress, contributing to understanding crocodilian stress and potentially informing improved farming practices for conservation and sustainable management.

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Slape, R.L. and Milic, N.L. (2024). Exploring the most common lesion of Australian farmed saltwater crocodile (*Crocodylus porosus*) belly skin in the Northern Territory. *Veterinary Journal* (doi: 10.1016/j.tvjl.2024.106174).

**Abstract:** This is the first descriptive study to characterise and identify the most common lesions on harvested Australian saltwater crocodiles (*Crocodylus porosus*). 88 skins were examined over a 17-month period as part of normal farming practices, 2901 lesions identified, with scale location, location of the lesion on the scale, and characteristics (contour, keratin normality, translucency and colour) recorded. The study determined that linear lesions accounted for 68.25% of lesions followed by foci lesions 17.24%. Lesions were distributed on the upper proportion of the belly skin (77.8%) and along the midline (72%). The most common lesion identified was a single translucent linear lesion across the scale that otherwise appeared normal (58.95%). While there is extensive research into pathogenic agents, further research is recommended to explore further causation of linear lesions, and factors that may contribute to their prevention. Given the subjective nature of crocodile skin grading, it is recommended future research into lesions is required to ensure the sustainability and profitability of the industry.

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.

**Abstract:** This chapter considers the prevalence of negative human-animal relations in communities surrounding Lake Kariba. People in different communities (ie Kariba town, fishing camps/villages and rural areas) are impacted in different ways by attacks from wild animals. As a result of human-wildlife conflict (HWC), people incur minor and serious injuries, death, loss of property and disruption of livelihoods. While the chapter generally refers to all animals (terrestrial and aquatic), detailed data of conflicts induced by crocodiles and hippos are given largely because the book is about the Lake. The HWC incidents and impacts are unevenly distributed across different social groups in the region. Among the fishing communities, for example, the most impacted are men because they engage in riskier activities and spend longer periods in the Lake compared to women and children. Overall, little is being done in terms of mitigating human-wildlife conflict at Lake Kariba and the chapter provides reasons for this. Consequently, humans continue to develop negative attitudes towards animals and, in retaliation for attacks, they resort to lethal means of dealing with the problem animals. Retaliation is a major threat to conservation at Lake Kariba, I argue.

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Matanzima, J. (2024). Epilogue: Towards mitigating the challenges faced by humans and animals at Lake Kariba. Pp. 309-332 in *The Materiality of Lake Kariba*. Palgrave Macmillan: Singapore.

**Abstract:** This book documents the interactions between Lake Kariba and communities living around it. The main focus has been on the materiality of the Lake, that is what it does to humans in different spaces and at different times. It is a first-of-its kind study to engage with the ways in which waterscapes and their material objects enable, and disable, the agency of humans mainly in connection to livelihoods, cross-border trade, tourism and fishing in the Zambezi Valley, Zimbabwe. Material objects of the Lake include crocodiles, hippos, strong winds, waves, river (ancestral) spirits and inundated graves. These material objects are not merely part of the water, as they shape lives and livelihoods as well as economies in the region. Because of these 'things', people die and suffer heavy losses. Given the many challenges faced at Kariba, in this concluding chapter, I provide several measures that could be used to mitigate them. This involves several suggestions around measures for mitigating human wildlife conflicts, human-human conflicts and the enhancement of people's access and use of the waterscape. Providing communities with increased access to the waterscape is necessary, as it is key to their history, identity, culture and religion.

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Rozada, L., Allain, R., Qvarnstrom, M., Rey, K., Vullo, R., Goedert, J., Augier, D. and Robin, N. (2024). A rich coprolite assemblage from Angeac-Charente (France): a glimpse into trophic interactions within an Early Cretaceous freshwater swamp. *Cretaceous Research* (<https://doi.org/10.1016/j.cretres.2024.105939>).

**Abstract:** Coprolites (fossil droppings) are common in the Mesozoic fossil record. However, coprolite assemblages from continental settings have more rarely been quantitatively analysed than the marine ones. The excavation of the Berriasian continental Lagerstätte of Angeac-Charente (France) during the last decade has resulted in unearthing a vast number of fossils, including ca. 6000 coprolite specimens. This large collection, accompanied by spatially landmarked depositional data, offers a unique opportunity to assess the organism interactions in an Early Cretaceous freshwater swamp ecosystem. We assign the coprolites to nine morphotypes based on their morphology and contents (using tomography and thin-sections), and to four taphonomic categories. We compare the specimens to other fossil and recent droppings, including newly imaged crocodilian faeces. While the Angeac-Charente biota comprised

animals of a range of different ecologies, including waters primary inhabitants (chelonians, crocodylomorphs, actinopterygians) and a variety of dinosaurs, the coprolites, together with other ichnological evidence, like bite marks, seem to largely illustrate the activity of the crocodylomorphs in this ancient swamp. The assemblage is compared to previously analysed continental Cretaceous copro-assemblages from Europe and North Africa.

Mascarenhas-Junior, P.B., Strickland, B.A., Heithaus, M.R., Santos, R.L., Barboza, R.S., Simões, P.I. and Correia, J.M. (2024). Artisanal fishing affects the local distribution of broad-snouted caiman (*Caiman latirostris*) within the Atlantic Forest of Brazil. *Aquatic Conservation: Marine and Freshwater Ecosystems* 34: e4214.

**Abstract:** Artisanal fishing is an important subsistence practice in freshwater habitats worldwide, but overexploitation threatens the conservation of several nontarget species including crocodylians. We investigated the effects of artisanal fishing on the distribution of a population of broad-snouted caiman (*Caiman latirostris*) inhabiting the Tapacurá reservoir, within the highly altered and threatened Atlantic Forest biome. We conducted spotlight surveys to detect caimans and gillnets deployed in the reservoir from April 2015 to June 2022. We evaluated temporal differences in gillnet encounter rates and the relationship between caimans and gillnet distribution. Gillnet encounter rates remained consistent year-round, while caiman encounter rates were highest near gillnets, especially in the river channel and in forested margins. Caimans are opportunistic predators attracted by tangled fish in gillnets and likely prefer habitats with increased fish abundance. Future research should continue monitoring the interaction between caimans and fishing and include local communities in conservation efforts.

Mazaratti, M.R., Valli, F.E., Pierini, S.E., Gonzalez, M.A., Piña, C.I., Cuffia, F., Simoncini, M.S. and Leiva, P.M.L. (2024). Physicochemical and sensory characterisation of *Salvator merianae* meat as a sustainable alternative. *International Journal of Food Science and Technology* (<https://doi.org/10.1111/ijfs.17167>).

**Abstract:** Considering the escalating consumer preference for health-conscious commodities, reptile species' meat can be presented as an alternative animal protein source because of its notable nutritional characteristics. The aim of this study was to evaluate the physicochemical parameters (pH, tenderness, cooking loss, colour and fatty acid profile) and sensory profile of black-and-white Tegu meat. The black-and-white Tegu meat was assessed through to consumer-based sensory Analysis alongside the Yellow Anaconda, Broad-snouted Caiman and broilers through. The samples of reptile species' meat were obtained from sustainable use programs. In terms of physicochemical parameters, the results indicate that black-and-white Tegu meat exhibits moderate brightness, displaying a pale pink/yellowish tone. Oleic acid was the most abundant fatty acid in black-and-white Tegu meat, comprising approximately 22.5%, while the content of polyunsaturated fatty acids was approximately 34%. Regarding overall liking, all four types of meats scored higher than indifference. However, black-and-white Tegu meat presented a lower acceptability ( $P < 0.001$ ), likely attributed to its dry texture and unpleasant colour, as perceived by consumers. Our findings underscore the need to explore preparation methods for enhancing the sensory characteristics of black-and-white Tegu meat. This will enable its promotion as a healthy food choice in the future. The utilisation of black-and-white Tegu meat as a food source will benefit families participating in the sustainable use and conservation program, the 'Proyecto Tupinambis'.

John, E.N. and Jones, K.R. (2024). Nutritional value of meat from selected neotropical reptiles. *Emerging Animal Species* 10 (<https://doi.org/10.1016/j.eas.2024.100046>).

**Abstract:** This is the second part of a two-part review. The first part

focused on the nutritive value of meat and meat products of selected neo-tropical mammals with the potential for domestication. The objective of this current review was to investigate the nutritional qualities and carcass traits of selected neotropical reptiles compared to domestic species, focusing on the spectacled caiman, iguana, tegu, and yellow anaconda. Carcass weight analysis revealed that the spectacled caiman and male iguana were efficient converters of live weight to edible carcass weight, with higher yields than other reptiles. Among domestic species, pigs and chickens showed higher carcass yields compared to cattle and lamb. Moisture content in reptile meat was generally higher than in domestic animals, impacting texture and juiciness. Protein content was lower in reptiles but still contributed to daily requirements, while fat content, though generally lower in reptiles, could impact flavor and tenderness. Cholesterol levels were lower in reptiles, particularly the yellow anaconda, making them potentially healthier options for those with cardiovascular concerns. Fatty acid composition analysis indicated varying levels of saturated, monounsaturated, and polyunsaturated fatty acids, with potential cardiovascular health benefits in reptile meats. Amino acid content, though lower in reptiles compared to domestic species, provided essential building blocks for various physiological functions. Overall, the study highlighted the nutritional value and potential health benefits of including neotropical reptile meat in the human diet, especially as alternative protein sources.

Espinara Cora, L.C. (2024). Influencia de las raciones alimenticias en el crecimiento de neonatos de *Caiman crocodilus* (Linnaeus 1758) en cautiverio con fines de conservación. Iquitos, Perú. BSc thesis, Universidad Nacional de la Amazonía Peruana, Peru.

**Resumen:** El estudio se realizó en el Centro de Custodia temporal y Zoológico "Fundo Pedrito", en el centro poblado Barrio Florido", distrito de Punchana, es una investigación cuantitativa de tipo experimental, se utilizó el Diseño Completamente al Azar (DCA) con nueve unidades experimentales distribuidas al azar para determinar la influencia de las raciones alimenticias en el desarrollo biológico de neonatos de *Caiman crocodilus* durante cuatro meses. El T1 fue el que obtuvo los mayores incrementos desde 7.0 g a 11.20 g, seguido del tratamiento T0 entre 4.30 g a 6.50 g y el que obtuvo los menores incrementos son los de tratamiento T2 con 3.0 g a 4.0 g. Sobre el largo total de los neonatos, el tratamiento T1 alcanzaron un largo total promedio de 17.47 cm, seguido por el T2 con promedio de 15.89 cm y en ultimo lugar el T0 con 14.9 cm. En el análisis de varianza, del largo total indica una alta diferencia estadística significativamente entre los tratamientos, el tratamiento que influye más en el crecimiento de los neonatos es el T1 (alimentados con peces) con un promedio de 17.47 cm, superando estadísticamente a los demás tratamientos, el coeficiente de relación muestra un nivel intermedio bajo de asociación del 44.25% entre el largo total y consumo de alimento. Sobre los pesos promedio, en T1 alcanzaron un mayor peso promedio de 46.44 g, seguidos por T2 con un peso de 45.67 g, mientras que el T0 con 34.78 g obtiene el menor peso, El análisis de varianza de los promedios de peso muestra que no existe significancia estadística, puesto que  $F_c = 0.15279133$  es menor a  $F_t = 5.14325285$ . Mientras que el análisis de varianza del consumo de alimentos muestra una alta diferencia estadística significativa entre tratamientos, puesto de  $F_c = 49.20941098^{**}$  es mayor a  $F_t = 18.51282051$ , por lo que la prueba de Duncan, indica que los promedios de los tratamientos T1 y T2 son absolutamente discrepantes entre sí, donde T1 ocupa el primer lugar con promedio de 599.66667 g superando estadísticamente a T2 que ocupó el puesto subsiguiente con promedio de 260.333333 g, el testigo no prosperó, estas variables muestran nivel de correlación medianamente alto del 79.08% de asociación entre el peso total sobre el consumo de alimento en neonatos.

**Abstract:** The study was carried out in the Temporary Custody Center and Zoo "Fundo Pedrito", in the Barrio Florido town center, district of Punchana, it is an experimental quantitative research, the Completely Random Design (DCA) was used with nine units. experimental experiments distributed randomly to determine the



influence of food rations on the biological development of *Caiman crocodrilus* neonates) for four months. T1 was the one that obtained the greatest increases from 7.0 g to 11.20 g, followed by treatment T0 between 4.30 g and 6.50 g and the one that obtained the smallest increases are those in treatment T2 with 3.0 g to 4.0 g. Regarding the total length of the neonates, treatment T1 reached an average total length of 17.47 cm, followed by T2 with an average of 15.89 cm and finally T0 with 14.9 cm. In the analysis of variance, the total length indicates a significantly high statistical difference between the treatments, the treatment that most influences the growth of the neonates is T1 (fed with fish) with an average of 17.47 cm, statistically surpassing the others. treatments, the relationship coefficient shows a low intermediate level of association of 44.25% between total length and food consumption. Regarding the average weights, in T1 they reached a highest average weight of 46.44 g, followed by T2 with a weight of 45.67 g, while T0 with 34.78 g obtained the lowest weight. The analysis of variance of the weight averages shows that There is no statistical significance, since  $F_c = 0.15279133$  is less than  $F_t = 5.14325285$ . While the analysis of variance of food consumption shows a high significant statistical difference between treatments, since  $F_c = 49.20941098^{**}$  is greater than  $F_t = 18.51282051$ , so the Duncan test indicates that the averages of treatments T1 and T2 are absolutely discrepant among themselves, where T1 occupies the first place with an average of 599.66667 g, statistically surpassing T2 who occupied the subsequent position with an average of 260.333333 g, the control did not prosper, these variables show a moderately high level of correlation of 79.08% of association between total weight on food consumption in neonates.

Nossa, D.N., Nóbrega, Y.C., Acosta, I.C.L., Santos, M.R.D., Menezes, P.Q., Heinemann, M.B., Souza Filho, A.F. and Srbek-Araujo, A.C. (2024). Antibodies against *Leptospira* spp. in free-living and captive Broad-snouted caiman (*Caiman latirostris*) and free-living Yacare caiman (*Caiman yacare*) in Brazil. Journal of Wildlife Diseases (<https://doi.org/10.7589/JWD-D-23-00185>).

**Abstract:** We evaluated antibodies against *Leptospira* spp. in both free-living and captive *Caiman latirostris* from Atlantic Forest, and free-living *Caiman yacare* from Pantanal, Brazil, by using a microscopic agglutination test. Overall seropositivity was 17%, with rates of 36% in captive *C. latirostris* (n= 4/11) and 18% in free-living *C. yacare* (n= 4/22).

Cavenaghi-Altemio, A.D., Santiago, L.L.S., Figueiredo, W.V. and Fonseca, G.G. (2024). Emulsified sausages obtained from mechanically separated meat of yacare caiman (*Caiman yacare*). Food Science and Technology 44 (<https://doi.org/10.5327/fst.00212>).

**Abstract:** This study aimed at the development and characterization of emulsified sausages using mechanically separated meat (MSM) from yacare caiman (*Caiman yacare*). The sausages were formulated using three different treatments containing (in %) 70.0 (T1), 75.0 (T2), or 80.0 (T3) of MSM of yacare and subjected to comprehensive analyses, including chemical composition, physical properties, microbiological safety, and sensory attributes. The proximate composition analysis revealed that moisture was the unique parameter that presented statistical differences between treatments, ranging from 74.94% (T1) to 72.35% (T3). pH and water activity measurements indicated stable and safe products, with high water activity attributed to water incorporation during emulsion formation. Color differences were observed among treatments, potentially linked to formulation, especially the MSM content. The highest average obtained for luminosity was 49.87 for T2, differing statistically ( $P > 0.05$ ) from T1 and T3. Consistent shear force values suggested effective emulsion formation and processing. The microbiological analysis demonstrated the safety of sausages, meeting microbial standards for consumption. Sensory evaluation revealed positive responses to appearance and aroma, while flavor and texture received mixed reviews. Purchase intention scores

indicated cautious consumer interest. Thus, further efforts are needed to optimize formulations and processing to enhance consumer sensory attributes to meet consumer preferences and improve acceptance, achieve marketability, and capitalize on the ecological and nutritional benefits of yacare caiman-derived products.

Villamarín, F., Jardine, T.D., Bunn, S.E., Malvasio, A., Piña, C.I., Jacobi, C.M., Araújo, D.D., Silva de Brito, E., de Moraes Carvalho, F., da Costa, I.D., Verdade, L.M., Lara, N., Barbosa de Camargo, P., Saikoski Miorando, P., Gonçalves Portelinha, T.C., Marques, T.S. and Magnusson, W.E. (2024). Body size predicts ontogenetic nitrogen stable-isotope ( $\delta^{15}\text{N}$ ) variation, but has little relationship with trophic level in ectotherm vertebrate predators. Scientific Reports 14(1) (doi: [10.1038/s41598-024-61969-5](https://doi.org/10.1038/s41598-024-61969-5)).

**Abstract:** Large predators have disproportionate effects on their underlying food webs. Thus, appropriately assigning trophic positions has important conservation implications both for the predators themselves and for their prey. Large-bodied predators are often referred to as apex predators, implying that they are many trophic levels above primary producers. However, theoretical considerations predict both higher and lower trophic position with increasing body size. Nitrogen stable isotope values ( $\delta^{15}\text{N}$ ) are increasingly replacing stomach contents or behavioral observations to assess trophic position and it is often assumed that ontogenetic dietary shifts result in higher trophic positions. Intraspecific studies based on  $\delta^{15}\text{N}$  values found a positive relationship between size and inferred trophic position. Here, we use datasets of predatory vertebrate ectotherms (crocodilians, turtles, lizards and fishes) to show that, although there are positive intraspecific relationships between size and  $\delta^{15}\text{N}$  values, relationships between stomach-content-based trophic level ( $\text{TP}_{\text{die}}$ ) and size are undetectable or negative. As there is usually no single value for  $^{15}\text{N}$  trophic discrimination factor (TDF) applicable to a predator species or its prey, estimates of trophic position based on  $\delta^{15}\text{N}$  in ectotherm vertebrates with large size ranges, may be inaccurate and biased. We urge a reconsideration of the sole use of  $\delta^{15}\text{N}$  values to assess trophic position and encourage the combined use of isotopes and stomach contents to assess diet and trophic level.

Müller, R.T. (2024). A new small-sized predatory pseudosuchian archosaur from the Middle-Late Triassic of Southern Brazil. Scientific Reports 14(1) (doi: [10.1038/s41598-024-63313-3](https://doi.org/10.1038/s41598-024-63313-3)).

**Abstract:** Before the rise of dinosaurs and pterosaurs, pseudosuchians-reptiles from the crocodilian lineage-dominated the Triassic land ecosystems. This lineage diversified into several less inclusive clades, resulting in a wide ecomorphological diversity during the Middle and Late Triassic. Some giant pseudosuchians occupied the top of the trophic webs, while others developed extensive bony armor as a defense mechanism, which later evolved as a convergence in the avemetatarsalian lineage. On the other hand, there were groups like the Gracilisuchidae, which was composed of carnivorous forms with lightweight build and less than 1 m in length. The fossil record of gracilisuchids is geographically restricted to China and Argentina, with one ambiguous record from Brazil. In the present study, the first unambiguous gracilisuchid from Brazil is described. *Parvosuchus aurelioi* gen. et sp. nov. comes from the Dinodontosaurus Assemblage Zone of the Santa Maria Formation, which is associated with the Ladinian-Carnian boundary. Composed of a complete cranium, vertebrae, pelvic girdle and hindlimbs, the new species nests with *Gracilisuchus stipanicorum* and *Maehary bonapartei* in a phylogenetic analysis. Its discovery fills a taxonomic gap in Brazilian pseudosuchian fauna and reveals the smallest known member of this clade from the Dinodontosaurus Assemblage Zone, highlighting the diversity of pseudosuchians during the moment that preceded the dawn of dinosaurs.

Rahman, R., Fraser, C.F. and Tumbelaka, L.I.T.A. (2024). The

growth in juvenile spectacled caimans at The Lost World of Tambun Malaysia. ARSHI Veterinary Letters 8(2): 37-38.

**Abstract:** The spectacled caiman needs to be better studied, and its basic life history needs to be explored. Growth rates and changes in growth with age and size are essential life history characteristics. This study aimed to determine the growth rate of juvenile spectacled caimans in captivity and understand the factors that affect the growth rate of juvenile spectacled caimans. Fourteen juvenile spectacled caimans were used in the present study. The study shows that the growth rate of all the juvenile spectacled caimans varied, where specimens such as Delta and 9th Dot had the highest growth rate in terms of weight at 0.98 g/day and 0.89 g/day, respectively. However, Little Foot had the lowest growth rates in snout-vent length and weight parameters at 0.03 cm/day and 0.08 cm/day. This study shows that the growth rate of juvenile spectacled caimans that dominance has a strong effect on the growth rate of juvenile spectacled caimans in captivity. Other factors that could be affected were social behavior, feeding behavior, and natural selection.

Benansio, J.S., Damaya, G.S., Funk, S.M., Fa, J.E., Di Vittorio, M., Dendi, D. and Luiselli, L. (2024). Attitudes and perceptions of local communities towards Nile crocodiles (*Crocodylus niloticus*) in the Sudd Wetlands, South Sudan. Animals 14: 1819.

**Abstract:** Conflicts between human populations and Nile crocodiles are widespread with crocodiles posing significant threats to fisherfolk and riverine communities across r-Saharan Africa. Hundreds of deadly attacks take place annually, and mortality rates may range from 50% to 100%. Attitudes and perceptions towards crocodiles were studied using structured questionnaires among fisherfolk along the River Nile and the Sudd wetlands in South Sudan. Local communities used crocodiles for their meat and skin/leather trades. The meat is regarded to enhance longevity, sexual potency, and protection against witchcraft. Crocodiles are perceived as a main threat to lives and livelihoods as they restrict people's freedom of movement along water bodies, attack livestock and humans, and devastate fishing equipment. To assess whether responses were influenced by the intensity of crocodile threats, published data on fatal crocodile attacks on humans and livestock were analysed using Generalised Linear Models (GLMs). This analysis indicated a direct link between the number of crocodile attacks and human attitudes. Crocodiles were generally feared and hated, and there was the agreement of the need to destroy breeding habitats. However, some attitudes were complex and nuanced as highlighted by the agreement of local communities on the need to destroy Nile crocodile breeding habitats on the one hand and the need to establish crocodile sanctuaries as the preferred strategy to mitigate risks and conflict on the other hand. There is a need for the creation of a crocodile sanctuary in the Sudd wetlands to minimise the risks of illegal hunting and to buffer the increasing pressure on crocodiles due to human population growth and economic upturn after the civil war.

Scarberry, N.E., Kelly, D.A., Martelli, P., Myburg, J., Piña, C.I., Mazaratti, M., Simoncini, M., Does, M., Sosa Rodríguez, G., Pérez Fleitas, E.A. and Moore, B.C. (2024). Crocodilian phallic malformations and anomalies. Journal of Herpetological Medicine and Surgery (<https://doi.org/10.5818/JHMS-D-23-00028>).

**Abstract:** Phallic malformations directly impact crocodilian copulatory function and thus could impact reproductive success in individual animals. This case series characterizes malformations observed and the implied reproductive consequences. We assessed a range of phallic malformations observed in saltwater crocodile (*Crocodylus porosus*), Nile crocodile (*Crocodylus niloticus*), broad-snouted caiman (*Caiman latirostris*), and Cuban crocodile (*Crocodylus rhombifer*) during veterinary examinations or postmortem studies and characterized observation into the following categories: amputation, phallic glans malformations, sulcus

spermaticus obstruction, and prolapse. Through detailed descriptions of these anomalies, we discuss potential reproductive health impact based on current knowledge across crocodilian species. When considering captive management of breeding stock, it is vital to examine individual efficacy at achieving proper intromission and insemination. Therefore, full reproductive examination in males should be part of routine examination to best manage individuals with such anomalies.

Górka, M., Březina, J., Chroust, M., Kowalski, R., López-Torres, S. and Taľanda, M. (2024). New data on Miocene crocodylians from the Fore-Carpathian Basin and its foreland. Pp. 35-36 in 10 International Workshop, Neogene of Central and South-Eastern Europe ([https://www.geo-zs.si/PDF/Monografije/10thNCSEE\\_Abstract\\_volume.pdf#page=35](https://www.geo-zs.si/PDF/Monografije/10thNCSEE_Abstract_volume.pdf#page=35)).

Paiva, A.L., Godoy, P.L., Dunne, E., Farnsworth, A., Valdes, P.J., Lunt, D.J., Klein, W., Langer, M.C. and Hsiou, A.S. (2024). The role of climate on the emergence of giant Caimaninae from the Miocene Western Amazonian Region. Available at SSRN: <https://ssrn.com/abstract=4873418> or <http://dx.doi.org/10.2139/ssrn.4873418>.

**Abstract:** Caimaninae includes the six modern species of caimans, which occur predominantly in South and Central America and are mostly medium-sized crocodylians. Nevertheless, the fossil record of the group unravels a significantly higher diversity, with remarkable body size variation. In particular, the giants *Purussaurus* and *Mourasuchus*, from the Miocene western Amazonian region, as two of the most prominent representatives. Previous work has demonstrated a correlation between the body size of crocodylians and abiotic factors throughout the Cenozoic; however, this relationship is poorly understood, particularly within the Caimaninae lineage. Here, we explore evolutionary body size patterns within Caimaninae, investigating the potential influence of climatic factors. Using a phylogenetically-informed method, we estimated the body size of 33 caimanine specimens, coupled with climatic variables from a General Circulation Model to reconstruct deep-time patterns. Our results indicate that giant Miocene caimanines are restricted to warmer conditions, with significantly less seasonal temperature variation. This suggests that the unmatching climatic conditions of the Miocene western Amazonian region possibly allowed the emergence of unique palaeoecosystems, favouring the sustenance of these very large crocodylians.

Úngari, L.P., Netherlands, E.C., Santos, A.L.Q., Viana, L.A., da Silva, R.J. and O'Dwyer, L.H. (2024). Is there only one species of *Hepatozoon* infecting Brazilian caimans? Integrative taxonomy unveiling the parasite's diversity. Brazilian Journal of Biology 84: e282989 (<https://doi.org/10.1590/1519-6984.282989>).

**Abstract:** *Hepatozoon* spp. are the most common haemoparasites reported from reptiles around the world, however, only six species have been described infecting crocodilians. In Brazil, *Hepatozoon caimani* Carini, 1909 is currently the only recognized species from the caiman hosts. This study provides new data on the diversity of species of *Hepatozoon* infecting *Caiman crocodilus* (Linnaeus) using molecular data and phylogenetic analysis, with additional support of morphological data of developmental stages from host blood and tissue. Forty-four individuals were collected and screened for haemogregarines, and blood and tissue samples were analysed by light microscopy with 31 (70.45%) infected. *Hepatozoon* spp. blood developmental stages included immature and mature gamonts with or without cytoplasmic vacuoles and free gamonts. Additionally, merogonic developmental stages were found in the liver and spleen of infected hosts. Based on the morphological and molecular data, this study identified two possible different species of *Hepatozoon*, being one of them the *H. caimani* with intragenotypic divergence.

**Resumo:** *Hepatozoon* spp. são os hemoparasitas mais comuns

relatados em répteis em todo o mundo, no entanto, apenas seis espécies foram descritas infectando crocodilianos. No Brasil, *Hepatozoon caimani* Carini, 1909 é atualmente a única espécie reconhecida dos hospedeiros jacarés. Este estudo fornece novos dados sobre a diversidade de espécies de *Hepatozoon* que infectam *Caiman crocodilus* (Linnaeus) utilizando dados moleculares e análise filogenética, com suporte adicional fornecido através de dados morfológicos de estágios de desenvolvimento do sangue e tecido do hospedeiro. Quarenta e quatro indivíduos foram coletados e triados para hemogregarinas, e amostras de sangue e tecidos foram analisadas por microscopia óptica com 31 (70.45%) infectados. Os estágios de desenvolvimento do sangue incluíram gamontes imaturos e maduros com ou sem vacúolos citoplasmáticos e gamontes livres. Além disso, foram encontrados estágios de desenvolvimento merogônico no fígado e baço de hospedeiros infectados. Com base nos dados morfológicos e moleculares, este estudo identificou duas possíveis espécies diferentes de *Hepatozoon*, sendo uma delas, o *H. caimani* com divergência intragenotípica.

Shankar, V.S., Purti, N. and Prabakaran, N. (2024). Snowballing trends of saltwater crocodile conflicts in Andaman Islands: A mounting concern for conservation and sustainable co-existence. *European Journal of Wildlife Research* 70: Article 67.

**Abstract:** Human-wildlife conflict is among the major constraint for wildlife management. It often can result in biodiversity decline and jeopardize the delicate balance of ecosystems. The human-saltwater crocodile conflict (hereafter referred to as HCC) is a major wildlife management issue in the Andaman and Nicobar Islands (ANI). Analyzing the long-term trends is vital for better understanding and management of HCC. We used diverse approaches like interviews with local community and victims, HCC register maintained by the Department of Environment and Forest (DoEF), and Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) to understand the patterns in the reported HCC events in ANI. During the past four decades (1983-2023), 36 fatal and non-fatal HCC were documented in the Andaman Islands. The HCC in ANI exhibited 75% increase after the catastrophic 2004 Indian Ocean tsunami. A comparison of gender involved in HCC indicates that men are often (56%) become victim of HCC owing to their frequent involvement in outdoor activities like fishing, swimming, farming, cattle rearing, etc. The highest number (79%) of HCC and crocodile sightings were documented during the wet season (June-December). The majority of HCC (53%) were reported in the creeks. South Andaman accounts for the highest number of HCC (53%) compared to the rest of the Andaman Islands. High relative frequency of sightings of saltwater crocodile in the creeks of South Andaman like Manglutan nallah (21.47), Dhanikhari nallah (16.56), Collinpur nallah (14.72), and Guptapara nallah (11.04) were recorded between 2016 to 2023. The current scenario demands an urgent need for more fundamental research focusing on the changes in Saltwater crocodile habitats post 2004 tsunami, factors driving the HCC, and development and implementation of an updated management plan to ensure the co-existence of humans and crocodiles in the ANI.

Liu, C., Wang, J., Liu, Z., Zhao, Z. and Zhang, G. (2024). Design and movement mechanism analysis of a multiple degree of freedom bionic crocodile robot based on the characteristic of “death roll”. *Journal of Field Robotics* (<https://doi.org/10.1002/rob.22380>).

**Abstract:** This paper introduces a multi-degree of freedom bionic crocodile robot designed to tackle the challenge of cleaning pollutants and debris from the surfaces of narrow, shallow rivers. The robot mimics the “death roll” motion of crocodiles which is a technique used for object disintegration. First, the design incorporated a swinging tail mechanism using a multi-section oscillating guide-bar mechanism. By analyzing three-, four-, and five-section tail structures, the four-section tail was identified as the most effective structure, offering optimal strength and swing amplitude. Each section of the tail can reach maximum swing angles

of 8.05°, 20.95°, 35.09°, and 43.84°, respectively, under a single motor’s drive. Next, the robotic legs were designed with a double parallelogram mechanism, facilitating both crawling and retracting movements. In addition, the mouth employed a double-rocker mechanism for efficient closure and locking, achieving an average torque of 5.69Nm with a motor torque of 3.92Nm. Moreover, the robotic body was designed with upper and lower segment structures and waterproofing function was also considered. Besides, the kinematic mechanism and mechanical properties of the bionic crocodile structure were analyzed from the perspectives of modeling and field tests. The results demonstrated an exceptional kinematic performance of the bionic crocodile robot, effectively replicating the authentic movement characteristics of a crocodile.

Vouiller, N. (2024). When animals kill people: a diversity of viewpoints and experiences around what might be called a catastrophe in Bardiya (south-west Nepal). In *Living in the Aftermath - Catastrophes in South Asia and the Himalayas*. Centre for South Asian and Himalayan Studies (CESAH): Paris.

**Abstract:** While the term ‘catastrophe’, which can be translated into Nepali as ‘āpatti’ (Turner, 1931, p. 35) or ‘durgati’ (ibid., p. 315) is absent from the interviews I have been conducting for five years now in Nepal around Bardiya National Park (BNP) on the subject of human-animal encounters, the definition given in the western world still seems accurate. The so-called Human-Wildlife Conflicts (HWC) in Bardiya can be seen as “brutal events that upset the course of things, often causing death and/or destruction”, as “accidents of great proportion” (CNRTL). In these encounters, which sometimes lead to death, it is clear that the terms unexpected, sudden, fear and violence are used. Psychomotor therapist and anthropologist, I study in my PhD the relations between humans and wild animals (tigers, rhinos, elephants, leopards, crocodiles mainly) in and around the BNP, particularly the experiences before, during and after they meet. As part of these conferences, my presentation, based on more than a year’s fieldwork and using a social science methodology (participant observation, semi-structured interviews, observations/descriptions, linguistic analysis, etc.), aims to question the term ‘catastrophe’ in this situation of encounters, since certain elements do not fit with it. It seems impossible to use the term correctly without specifying the type of event (attack or simple encounter, first time or not, endangerment or misfortune?), the resources of the person concerned (compensations after?) and the job they perform (benefits or not from wildlife?), but also the way in which this person recovers from this encounter (storytelling, valorization...), the way in which the event is broadcast or dramatized (newspapers, admiration...). Indeed, not all human-animal encounters are “conflicts”, and they do not all result in “death and/or destruction.” Second, not all of my informants see themselves as victims, or sometimes even the situations as accidents. Finally, even if tensions have increased significantly in Bardiya the last years, the way in which they are managed by the State does not necessarily suggest a “brutal event” and could be seen as a way of domination, in the context of a catastrophe which does not end, without going back... Following on from a conference given on the theme of crises three years earlier, I intend to address how these encounters represent ruptures (ecological, financial, political, social, psychocorporal) for humans living in Bardiya and in particular how the points of view/subjectivities around what we could call “catastrophe” (or rather catastrophes) vary and are central.

Walter, J.D., Marramà, G., Pavia, M., Carnevale, G. and Delfino, M. (2024). A shark turns into an undetermined crocodylian: The case of *Acanthias bicarinatus* Sismonda, 1849. *Bollettino della Società Paleontologica Italiana* 63(1): 83-87.

**Abstract:** The holotype and only specimen referred to the Early Miocene shark *Acanthias bicarinatus* Sismonda, 1849 is housed in the collections of the Museo di Geologia e Paleontologia dell’Università degli Studi di Torino and was collected from the



serpentinite sandstone of the middle-late Burdigalian Termofourá Formation of the Torino Hill. The specimen, formerly interpreted as a fragment of a squalid dorsal-fin spine, is reinterpreted herein as an isolated crocodylian tooth. The validity of the species *Acanthias bicarinatus* is therefore reconsidered and referred to as a nomen dubium. The tooth, replaced while the crocodylian was alive, was deposited in a near-shore marine environment at a time when modern crocodylian lineages were already widespread along the northern sector of the Mediterranean area.

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Correction to: “Murphy, K.M., Watkins, M.M., Finger, J.W. Jr., Kelley, M.D., Elsey, R.M., Warner, D.A. and Mendonça, M.T. (2022). Xenobiotic estradiol-17 $\beta$  alters gut microbiota of hatchling American alligators (*Alligator mississippiensis*). Environmental Microbiology 24(12): 6336-6347.” Published Erratum in Environmental Microbiology 26(6): e16667.

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Avilés Argueta, C.R. (2024). Tamaño y Estructura Poblacional de Caiman de Anteojos (*Caiman crocodilus*) en el Área Natural Protegida Santa Rita, Ahuachapán. BSc thesis, Universidad de El Salvador, San Salvador, El Salvador.

**Abstract:** La presente investigación fue realizada con el objetivo de identificar el tamaño y estructura poblacional de *Caiman crocodilus* en el Área Natural Protegida Santa Rita en el municipio de San Francisco Menéndez, Ahuachapán, El Salvador. Se realizaron un total de 42 monitoreos durante 21 días en los 3 sectores definidos para el muestreo entre los meses mayo a octubre de 2021. Durante cada jornada se registraron datos sobre avistamientos y capturas, los cuales consistían en: morfometría, sexo, temperatura, peso, categoría; así como datos de las zonas de captura (georreferencia, temperatura del agua, temperatura ambiente, hora, etc.). Se obtuvieron un total de 27 registros visuales con una TE= 0.24 ind/km, con una densidad poblacional de 0.14 ind/hectárea y una estimación poblacional de 41.30 individuos. Las observaciones totales durante el muestreo fueron: 12 capturas (44%), 5 avistamientos (19%) y 10 rastros (37%), de estos 11(47%) avistamientos se realizaron en el sector Río Sacramento. Los promedios de temperatura de agua medidos en cada observación presentan una distribución similar, donde los valores más altos corresponden a RS: 25.73°C, PZ: 24.81°C y EC: 24.3°C. Los valores de temperatura registrados en cada captura se encontraron entre los 27.2°C y los 23.8°C, encontrando los individuos de mayor tamaño a temperaturas menores a los 26°C. La estructura poblacional por tallas mostró una marcada mayoría de individuos de la clase I (Crías) la cual representó el 44% de avistamientos con 8 individuos, seguidos por 4 clase II (20%), 3 clase III (15%), 2 clase IV (10%) y 3 clase V (15%), la distribución por tallas presentó normalidad al aplicar una prueba de normalidad (Shapiro-Wilk)  $p= 0.813$ . La distribución por sexos mostró una clara mayoría de hembras (80%) durante todo el muestreo, con una relación de machos/hembras de 1:4. Los datos obtenidos serán valiosos para posteriores investigaciones en este grupo, así como para reconsiderar el estatus de la especie a nivel nacional.

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Chinnadurai, S.K. and Mosley, C.I. (2024). Comparative anesthesia and analgesia - reptiles, amphibians, and fishes. Chapter 57 in Veterinary Anesthesia and Analgesia: The Sixth Edition of Lumb and Jones, ed. by L. Lamont, K. Grimm, S. Robertson, L. Love and C. Schroeder. John Wiley & Sons: New York.

**Abstract:** Reptiles, amphibians, and fishes are unique animal classes encountered in veterinary medicine and are very different in terms of anatomy, physiology, and behavioral adaptations from the more familiar mammals. Regardless of the differences among these animal classes, by using sound anesthetic principles, reasonably safe and effective anesthesia can be performed, even in the absence of species-specific information. This chapter emphasizes comparative anatomic and physiologic information relevant to the anesthetic management of each class of animals.

Boucher, M., Rainwater, T.R., Stoner, M., Sigler, L., Whitmire, S.L. and Anderson, J.T. (2024). Conquering the crush: A novel tool for holding crocodilian jaws open. Wildlife Society Bulletin (doi: 10.1002/wsb.1534).

**Abstract:** Crocodilians have diverse snout shapes ranging from the long, narrow snouts of the Indian gharial (*Gavialis gangeticus*) to the broad snout of the American alligator (*Alligator mississippiensis*). In addition, crocodilians possess the strongest bite force of all extant animals, with recorded values for adult alligators exceeding 9 kilonewtons (kN). Jaw-closing pressure poses a challenge and safety risk for people working with crocodilians, such as veterinarians, wildlife managers, and researchers who must safely access the oral cavity to perform veterinary procedures, health assessments, hook removals, or sample collection. Conventionally, polyvinyl chloride (PVC) or metal tubes (pipes) placed longitudinally into the mouth have been used to hold crocodilian jaws open for such operations. The short sections of opaque pipe can cause oral irritation, obscure the palate and tongue, and restrict access to the oral cavity and palatal valve. In conjunction with a project investigating the diet of alligators in the southeastern United States, we identified a need to create an efficient tool to allow safe and direct access to the alligator oral cavity. We built 2 versions of a device for holding alligator jaws open that are adjustable to accommodate different gape sizes. The device allows for safe positioning within the mouth, includes safety considerations for device failure, and is adaptable to both widen and collapse the gape of the mouth. We successfully deployed and recovered the device on 76 wild alligators ranging in total length from 120 to 329 cm. We also performed mechanical tests in the laboratory to assess the maximum force the devices and associated materials can safely withstand, as well as the conditions under which the devices fail. Our medium-duty and heavy-duty device designs withstood forces up to 6 kN and 18 kN, respectively. We observed no material fracture in the devices but did observe deformations of materials used during laboratory testing. The device is an inexpensive and effective tool for veterinarians, wildlife researchers, and managers who need to hold open the jaws of crocodilians safely.

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Lopes-Lima, M., Prie, V., Camara, M., Ceriaco, L.M.P., Fernandes, V., Ferreira, S., Goncalves, D.V., Lecoq, M., Martins, F.M.S., Parrinha, D., Regalla de Barros, A., Valentini, A., Verissimo, J., Palma, L. and Beja, P. (2024). Rapid eDNA survey reveals a unique biodiversity hotspot: The Corubal River, West Africa. BioScience (https://doi.org/10.1093/biosci/biae036).

**Abstract:** The Corubal (Guinea-Bissau) is a wild but underexplored river in West Africa. This study underscores the potential of environmental DNA (eDNA) surveys to fill biodiversity knowledge gaps in the region. We filtered large water volumes at 11 sites along the watershed, amplified multiple molecular markers, and performed high PCR (polymerase chain reaction) replication and in-depth sequencing. We recorded 2589 amplicon sequence variants, with accumulation curves indicating the need for additional sampling to achieve a thorough survey. The taxonomic assignments were constrained by the scarcity of genomic resources. We recorded 125 species of aquatic and terrestrial vertebrates, including 21 new to the country, predominantly fish (61.9%). Surprisingly, crocodiles were not detected, despite their known presence. There were 11 imperiled species, two of which are Critically Endangered (Western chimpanzee and the mussel *Pleiodon ovatus*). Our findings support the conservation importance of the Corubal, provide a baseline for future monitoring, and highlight the challenges and opportunities of eDNA surveys in remote tropical rivers.

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Hakim, J. and Sharma, J.P. (2024). Mugger crocodile *Crocodylus palustris* (Lesson, 1831) predation on Brown Fish Owl *Ketupa zeylonensis* (J.F. Gmelin, 1788), with notes on existing literature regarding their predation on birds

**Abstract:** Several observers have noted that Mugger Crocodiles

*Crocodylus palustris* incorporate birds into their diet, though no authors have reviewed the full range of bird species subject to such predation. In the present study, the first observation of Mugger Crocodile predation on an owl, specifically the Brown Fish Owl *Ketupa zeylonensis*, is reported. Additionally, the existing literature regarding Mugger Crocodile predation on birds is summarized.

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Wallwork, M. (2024). The Effects of Human-driven Land Use Change on American Alligator (*Alligator mississippiensis*) Nesting Patterns. MSc thesis, University of North Florida, USA.

**Abstract:** American alligators (*Alligator mississippiensis*) have received little scientific attention in the context of human-driven land use change. The goal of my study is to investigate how land use change may be affecting the spatial ecology of alligator nesting in Florida. Areas directly impacted by humans are growing rapidly in Florida, yet the impacts of this land use change on alligator populations and reproduction are largely unknown. Alligators are ecosystem engineers and apex predators, and their nests often double as nests for other reptilian species. Therefore, it is imperative that we understand how human-driven land use change may be impacting alligator nest site preferences and reproduction. Using historical nest GPS data, human footprint data, and data from the National Land Cover Database I examined the effects of human-driven land use change on alligator nesting patterns across ten Florida lakes. I did not find almost any statistically significant difference between alligator nesting patterns in high human impact areas and low human impact areas. This result agrees with a growing body of literature that shows wildlife tend to respond more strongly to direct interactions with humans compared to indirect interactions with human impacts on the surrounding landscape. My results suggest that as long as alligator nesting habitat stays intact and usable, female alligators appear to be willing and able to nest in areas of relatively high levels of human impacts.

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Crossley II, D., Crossley, J.L., Conner, J., Smith, B., Elsey, R.M., Nelson, D. and Wang, T. (2024). Temperature effects on blood gases in embryonic American alligators (*Alligator mississippiensis*). Available at SSRN: <https://ssrn.com/abstract=4869337> or <http://dx.doi.org/10.2139/ssrn.4869337>.

**Abstract:** Numerous studies report on the influence of temperature on blood gases in ectothermic vertebrates, but there is merely a cursory understanding of these effects in developing animals. Animals that develop in eggs are at the mercy of environmental temperature and are expected to lack the capacity to regulate gas exchange and may regulate blood gases by means of altered conductance for gas exchange. We, therefore, devised a series of studies to characterize the developmental changes in blood gases when embryonic alligators were exposed to 25, 30 and 35°C. To determine how blood parameters were impacted by changes in embryonic temperature, blood was sampled from the chorioallantoic membrane artery. The blood in the chorioallantoic membrane artery is a mixture of oxygen-poor and oxygen-rich blood, which based on the embryonic vascular anatomy may reflect blood that perfuses the chemoreceptors of the developing animal. Our findings indicate that following a 48 h exposure to 25°C or 35°C, there was a positive relationship between CAM artery blood PO<sub>2</sub>, PCO<sub>2</sub> and glucose. However, blood pH suggests embryonic alligators lack an acute regulatory mechanism for adjusting blood pH.

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Myburgh, A., Viljoen, D.M., Myburgh, J.G., Downs, C.T., Webb, E.C. and Woodborne, S. (2024). Low-cost uncrewed aerial vehicles (UAVs) as a novel tool for welfare assessments on open pen commercial crocodile farms. Journal of the South African Veterinary Association 95(1): 88-94.

**Abstract:** The welfare of crocodiles on commercial farms in southern Africa requires precise assessment, focusing on stocking densities

and pen conditions. However, disputes between animal welfare groups and farm owners persist due to inadequate methodologies for quantifying these factors. This study aimed to address these disputes and enhance crocodile welfare assessment by introducing a novel technique using a low-cost consumer uncrewed aerial vehicle (UAV) and open-source photogrammetry software. The objective was to quantify key welfare parameters accurately and efficiently. The study involved applying the UAV-based technique to two large Nile crocodile (*Crocodylus niloticus*) farms in South Africa. The approach enabled the mapping and surveying of crocodile pens, facilitating the determination of stocking densities, biomass indicators, and other pen-related attributes. Comparisons were made between UAV-derived crocodile counts and farmer estimates. The UAV-based crocodile counts significantly differed from the estimates provided by farmers, underscoring the need for a more precise assessment method. The technique's cost-effectiveness was evident, with implementation expenses totalling less than R10,000, a fraction of the cost associated with commercial UAV surveys. The introduced UAV-based technique offers a valuable solution to the ongoing debates regarding crocodile welfare on commercial farms. By quantifying key parameters accurately and economically, it empowers farmers and animal welfare groups to make informed decisions. The method's ease of adoption, demonstrated through its use by some Southern African crocodile farmers, signifies its potential for widespread application, ultimately contributing to improved crocodile welfare.

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Cubas-Rodríguez, A.M. and Cupul-Magaña, F.G. (2024). A record of a non-fatal attack of an American crocodile (*Crocodylus acutus*) in the "Rio Segovia" on the Honduras-Nicaragua border. Neotropical Biology and Conservation 19(2): 63-66.

**Abstract:** A case of a non-fatal crocodile attack on a human was reported on the banks of the Segovia River on the Honduras and Nicaragua border. The 12-year-old girl survived the attack, only with damage to the tibia of her right leg, where she lost part of the muscle tissue due to the bite. It was after the attack that the American crocodile was shot and killed by local people. In this paper, we discuss the possible causes of crocodile attacks.

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Heck, C.T. and Woodward, H.N. (2024). The consequences of calcium: investigating intracortical reproductive signals in the American alligator for sex determination. The Anatomical Record (doi: 10.1002/ar.25533).

**Abstract:** Identifying sex in extinct archosaurs has proven difficult due, in part, to low sample sizes, preservation biases, and methodology. While previous studies have largely focused on morphological traits, here we investigate intracortical signals of egg-shelling in extant alligators. Egg-shelling requires large mobilizations of calcium reserves. Aves utilize medullary tissue as a calcium reserve, whereas crocodylians mobilize calcium from cortical bone or osteoderms. If crocodylians derive calcium from bone cortices for egg-shelling, then egg-shelling events should be detectable in female crocodylian cortical bone. We examined mid-diaphyseal *Alligator mississippiensis* femoral bone cross-sections for signals of reproduction. Compaction and area of resorbed tissue were measured in femoral cross-sections from captive raised male (n= 10) and female (n= 29) *A. mississippiensis* of 26-27 years at age of death. This sample is more robust than previous studies, though reproductive history data is unknown. Femora from a small sample of wild caught male (n= 6) and female (n= 6) *A. mississippiensis* were also measured. Data were analyzed by pairwise t-tests between sex and captivity status. There was no significant difference in either compaction or resorbed tissue values between male and female alligators, regardless of habitat (wild or captive-raised). A reproductive signal was undetectable in this study and any quantifiable differences between sexes appears to be driven by size dimorphism. Cortical resorption rates in the femora of male and female alligators are reflective of normal aging processes and

not indicative of egg-shelling during reproduction. Examination of younger alligators would clarify processes driving bone turnover during reproductively active years.

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Jancovich, B.A. and Rogers, T.L. (2024). BASSA: New software tool reveals hidden details in visualisation of low-frequency animal sounds. *Ecology and Evolution* 14(7): e11636.

**Abstract:** The study of animal sounds in biology and ecology relies heavily upon time-frequency (TF) visualisation, most commonly using the short-time Fourier transform (STFT) spectrogram. This method, however, has inherent bias towards either temporal or spectral details that can lead to misinterpretation of complex animal sounds. An ideal TF visualisation should accurately convey the structure of the sound in terms of both frequency and time, however, the STFT often cannot meet this requirement. We evaluate the accuracy of four TF visualisation methods (superlet transform [SLT], continuous wavelet transform [CWT] and two STFTs) using a synthetic test signal. We then apply these methods to visualise sounds of the Chagos blue whale, Asian elephant, southern cassowary, eastern whipbird, mullet fish and the American crocodile. We show that the SLT visualises the test signal with 18.48%-28.08% less error than the other methods. A comparison between our visualisations of animal sounds and their literature descriptions indicates that the STFT's bias may have caused misinterpretations in describing pygmy blue whale songs and elephant rumbles. We suggest that use of the SLT to visualise low-frequency animal sounds may prevent such misinterpretations. Finally, we employ the SLT to develop 'BASSA', an open-source, GUI software application that offers a no-code, user-friendly tool for analysing short-duration recordings of low-frequency animal sounds for the Windows platform. The SLT visualises low-frequency animal sounds with improved accuracy, in a user-friendly format, minimising the risk of misinterpretation while requiring less technical expertise than the STFT. Using this method could propel advances in acoustics-driven studies of animal communication, vocal production methods, phonation and species identification.

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Leeds, A., Riley, A., Stalter, L., Terry, M., Alba, A.C. and Soltis, J. (2024). Investigating the relationship between abiotic factors and the behaviour of an All-Male Nile crocodile (*Crocodylus niloticus*) Group. *Applied Animal Behaviour Science* 277 (<https://doi.org/10.1016/j.applanim.2024.106338>).

**Abstract:** Abiotic factors can have notable effects on animal behaviour at both seasonal and daily time scales. Understanding these effects is a critical consideration in the management and welfare of animals

in human care. Herein we evaluated social behaviour and space use patterns of an *ex-situ* all-male Nile crocodile (*Crocodylus niloticus*) group in relation to seasonal (month) and daily (temperature, humidity, precipitation, time of day) abiotic factors over two years. Our results suggest that abiotic factors have notable influences on Nile crocodile behaviour at both seasonal and daily time scales. Seasonal patterns of behaviour were distinct, particularly between winter-spring and summer. Agonism rates during winter-spring were twice that of those in summer. Wounding was low throughout the year; however, the odds of having a wound increased by at least a factor of six during the winter compared to all other seasons. Also, sociosexual behaviour was almost exclusively observed within three months during the winter-spring seasons. These changes suggest this *ex-situ* all-male group's social structure was seasonally variable in a manner that appears similar to reproductive seasonal changes observed in *in-situ* crocodile populations. Additionally, the odds of a crocodile being in water were nearly five times greater in the summer than winter-spring, likely reflective of seasonal differences in thermoregulatory requirements. Daily atmospheric conditions had generally weaker influences on behaviour than season; however, notable changes were observed suggesting daily abiotic variation is an important consideration in crocodile management. For example, morning rates of agonism were 1.5 times greater than afternoon rates, and the odds of a crocodile being in water were 73% greater in the morning than afternoon. Collectively, these findings emphasize that care and welfare decisions based on behavioural inference may be incomplete, or worse inaccurate, if abiotic influences are not considered.

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Putra, T.A.D. (2024). Potential of Asam Kumbang Crocodile Breeding as a Tourist Destination in Medan City. Diploma thesis, Universitas Sumatera Utara, Medan, Indonesia.

**Abstract:** Medan is the capital of North Sumatra Province, has high historical value and natural tourism as a tourist object and attraction. One tourist attraction with great potential is the Asam Kumbang crocodile farm in the Medan Sunggal area. This crocodile farm has been designated as the largest crocodile farm in the world. The area of the Asam Kumbang crocodile breeding area is  $\pm 2$  ha. In the Asam Kumbang crocodile breeding area there are  $\pm 2800$  crocodiles which are cared for and preserved by the management. Until now, the Asam Kumbang crocodile farm is less attractive to tourists due to the low level of cleanliness of the breeding area and the lack of promotional efforts made by the management. This Asam Kumbang tourist attraction has great potential if it is developed into interesting tourist attraction. The area around the Asam Kumbang crocodile farm is still natural because the crocodile farm is still far from the noise and pollution of the city.



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