

CROCODILE SPECIALIST GROUP NEWSLETTER

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CROCODILE

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GROUP

NEWSLETTER

VOLUME 43 Number 3
JULY 2024 - SEPTEMBER 2024

IUCN Species Survival Commission

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Cover: Leucistic 3-m female Estuarine crocodile (*Crocodylus porosus*) in Bhitarkanika National Park, Odisha, India. See pages 10-17. Photograph: Nimai - Bhakta.

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CSG Newsletter

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

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Editorial

At the meeting of the CSG Steering Committee held in April 2024, the Executive Committee announced its intention to establish an Executive Advisory Group (EAG). The EAG will aim to achieve some of the goals set by the Future Leaders Program during its period of operation, but its main role will be for the group to work closely with the Executive Committee at a more strategic level. The EAG currently comprises Sergio Balaguera-Reina, Matthew Brien, Venetia Briggs-Gonzalez, Xander Combrink, Curt Harbsmeier, Steve Platt, Christy Plott, Matthew Shirley, Melina Simoncini and Pablo Siroski. Initial activities include revision/development of: a communication strategy; a fundraising strategy; and, crocodilian conservation priorities. The EAG will draw on expertise from within the CSG membership as required.

Following discussions at the recent CSG Working Meeting (Darwin, April 2024), an Ecotoxicology Working Group was recently established, with Dr. Jérémy Lemaire as Chair. It is envisaged that the working group will initially comprise a small cohort of members to participate in the development of terms of reference, before the group is expanded in membership. The Human-Crocodile Conflict Working Group was also re-formed after the working meeting, with Simon Pooley as Chair and general oversight by EAG member Matt Brien.

We express our deep sorrow and sadness on the passing of CSG member Gustavo Casas Andreu (1943-2024). Dr. Casas Andreu was considered a pioneer and pillar of Mexican herpetology, including studies on crocodiles in Mexico. He was a lifetime member of the Mexican Society of Zoology and the Mexican Herpetological Society, a founding member of the Association for the Research and Conservation of Amphibians and Reptiles and the Crocodilian Specialist Group of Mexico (GEC-MX), and a member of SOS Cocodrilo México. His long and illustrious career leaves an indelible mark on our memories and remains a source of inspiration for generations to come, particularly in the Latin America and Caribbean region.

Summer CrocFest 2024 was successful in raising \$US62,000 for conservation efforts for Cuban (*Crocodylus rhombifer*) and American (*C. acutus*) crocodiles in Cuba. We again congratulate CrocFest organisers Curt Harbsmeier, Colette Adams, Flavio Morrissiey and their team, and participants, for another very successful event. A more detailed report on the event is on pages 23-24.

Alejandro Larriera was invited by the UNEP Regional Office to a workshop on "Nature Based Solutions", held in Rio de Janeiro on 9-10 September 2024. Alejandro joined others from

different disciplines, working in environmental conservation. Alejandro was asked to talk about the influence of the CSG on promoting the creation of incentives through the sustainable use of crocodilians. Interesting outputs resulted from the interactive work between the different specialists.

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 9 students in the July-September 2024 quarter (see below), and one application is currently under review.

1. Luis Lozada Lobaina (Cuba): Captive management of *Crocodylus acutus* neonates for population strengthening in the Monte Cabaniguan sector, Cuba.
2. Ana Maria Saldarriaga-Gómez (Colombia): Monitoring *Crocodylus intermedius* nests and hatchlings in Colombia: A hope for recovering the species.
3. Murilo Dos Reis (Brazil): Parental care in *Caiman latirostris* (Crocodylia: Alligatoridae) in a coastal environment population in Brazil.
4. Ryan Johnston (Australia): Application of chimeric antigens to paper-based diagnostics for detection of WNV in *Crocodylus porosus*.
5. Fernando Paulino Alvarenga (Brazil): Comparison of ecological niches among evolutionary units of *Caiman latirostris* (Daudin, 1802).
6. Andreas Rani Agon (Indonesia): Density of Saltwater crocodile (*Crocodylus porosus*) and crocodile-human conflict in Menipo Natural Recreation Park, Kupang District, East Nusa Tenggara.
7. David Andrade Dominguez (Ecuador): Trophic magnification of mercury in food webs of *Crocodylus acutus* in rivers on the Ecuador-Peru border.
8. Carlos Rodrigues (Brazil): Parasitic ecology and ecotoxicology of *Caiman latirostris* (Daudin, 1802) in the Capibaribe River basin, northeast Brazil.
9. Fortunate Davhana (South Africa): Experimental study investigating the effect of ingested lead in captive Nile Crocodiles (*Crocodylus niloticus*): Significant for wild population.

A detailed review of the SRAS and FHVS-SRAS programs since they were established is on pages 4-7.

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

CSG Student Research Assistance Schemes - A Review

The CSG's Student Research Assistance Scheme (SRAS) was established in 2009, with the specific goal to encourage and assist undergraduate and postgraduate students to undertake formal research on crocodilians, particularly field research. In 2014, the Fritz Huchzermeyer Veterinary Science Student Research Assistance Scheme (FHVS-SRAS) was established, with a focus on veterinary science research. The SRAS and FHVS-SRAS programs have thus been in operation for 15.75 and 10.75 years, respectively.

Since the inception of SRAS, the CSG has received 291 applications for funding (278 SRAS, 13 FHVS-SRAS), of which 260 (89.7%) were approved for funding (\$US1000 per project). One of the successful applicants (Costa Rica, 2009) withdrew from their project, and returned the funding, leaving 259 projects being funded up to September 2024 (Fig. 1). One application (Mexico) is currently under review.

The number of grants issued annually has varied between a low of 4 (in 2016) and a high of 29 (in 2018) (Fig. 1), with averages of 15.6 SRAS/year and 1.2 FHVS-SRAS/year (overall= 16.4/year).

Review Process

When an application is received, a compliance check ensures that all required information is included and the proponent is asked to resubmit if the application is incomplete. The most non-compliant items are not including letters of support from either the academic supervisor and/or a CSG member, or not answering all questions on the application form.

The application is then sent out for review to at least three CSG members with expertise in the project area. Reviews are usually received within 2-3 weeks. Recently, a reviewer response form was created to streamline the review process. Reviewer responses are then collated and, in the majority of cases, approval is recommended to the CSG Chair/s for endorsement. On occasion, projects are requested to be resubmitted after considering the feedback provided by reviewers (Table 1).

Table 1. Categorisation of 30 unsuccessful SRAS applications, 2009-September 2024.

| Category | N | Later Successful |
|--|----|------------------|
| Not eligible | | |
| Not enrolled in university | 1 | 1 |
| Study already completed | 1 | - |
| Post-doctoral research | 1 | - |
| Incomplete applications; invited to resubmit | 2 | - |
| Not accepted; major revision requested | 23 | 5 |
| Accepted subject to minor revision | 2 | - |
| Totals | 30 | 6 |

Once approved by the Chair/s, the recipient is informed of the successful application. At this time, reviewer comments are also provided for the recipient to consider, and a request is made for their bank details and a photograph for inclusion on the [website](#). Of importance, the CSG members who reviewed

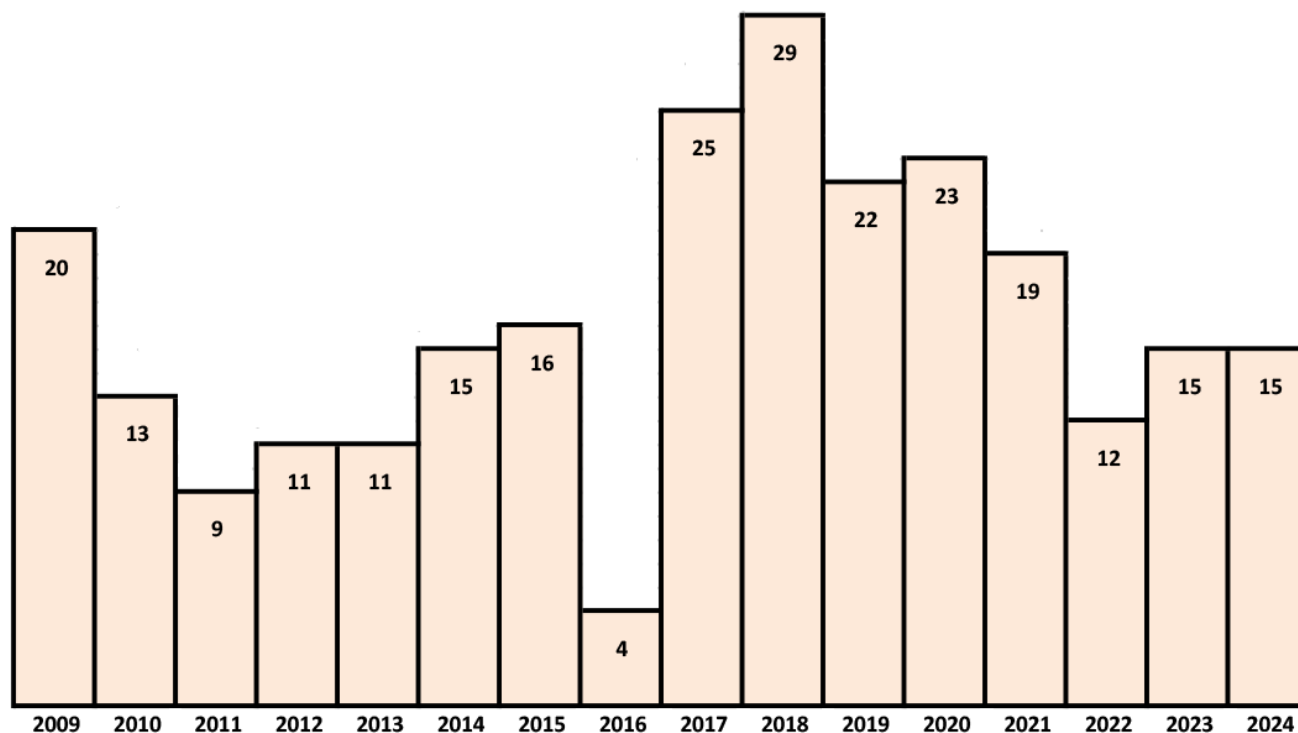


Figure 1. Numbers of SRAS and FHVS-SRAS applications approved each year, 2009-September 2024. One application currently under review in 2024 is not included.

the application are also informed of the final decision and thanked for taking the time to review it.

Unsuccessful Applications

Of the 30 students who were not successful with their SRAS applications, 23 (77%) were not accepted mainly due to project methodology being considered inadequate, and major revision was recommended (Table 1). However, five applications in the same year (2022) from the same country involved very similar applications, with the research location simply being changed.

The review process (see earlier) provides feedback to unsuccessful applicants, and there is an opportunity for the unaccepted applications to be modified accordingly, and re-

submitted. Indeed, 6 students later submitted applications on different topics that were successful, with an average of 4 years between applications (range 0 to 7 years).

Qualifications Sought

Qualifications being sought by the 259 successful applications were; PhD (94; 36%), MSc (98; 38%), BSc/Hons (62; 24%) and Post-doctorate (5; 2%). Nine students were awarded SRAS funding twice, as they were continuing on to higher qualifications [BSc-PhD (1), MSc-PhD (6), PhD-Post-doc (2)].

Although post-doctoral research does not strictly comply with SRAS guidelines, of the 6 applications received to date, 5 were approved and one was not approved. Each application

Table 2. Origin of student and research location for 259 successful SRAS applications, 2009-September 2024.

| Country/Region | Student From | Study Location | Country/Region | Student From | Study Location |
|--------------------------------------|--------------|------------------------|-----------------------------------|--------------|-----------------------|
| China | 3 | 4 | Australia | 6 | 9 |
| Indonesia | 1 | 3 | Timor Leste | - | 1 |
| Malaysia | - | 2 | Australia & Oceania | 6 | (2%) 10 (4%) |
| Philippines | 4 | 6 | USA | 35 | 21 |
| Thailand | 1 | 1 | Canada | 1 | - |
| Vietnam | - | 1 | North America | 36 | (14%) 21 (8%) |
| East & Southeast Asia | 9 | (3%) 17 (7%) | India | 7 | 8 |
| Belgium | 1 | - | Iran | 1 | 1 |
| Denmark | 3 | - | Nepal | 13 | 13 |
| France | 5 | - | Pakistan | 1 | 1 |
| Germany | 3 | - | Sri Lanka | 1 | - |
| Ireland | 1 | - | South Asia & Iran | 23 | (9%) 23 (9%) |
| Netherlands | 1 | 1 | Africa (multi-country) | - | 1 |
| Norway | 1 | - | Botswana | - | 2 |
| Poland | 1 | - | Egypt | 1 | - |
| Portugal | 3 | - | Ethiopia | 2 | 2 |
| United Kingdom | 7 | 1 | Kenya | 1 | 2 |
| Europe | 26 | (10%) 2 (1%) | Namibia | 1 | 2 |
| Greater Antilles | - | 1 | Rwanda | 1 | - |
| Argentina | 26 | 27 | South Africa | 19 | 17 |
| Belize | - | 9 | Uganda | 3 | 1 |
| Bolivia | 2 | 2 | Zambia | 1 | 1 |
| Brazil | 27 | 27 | East & Southern Africa | 29 | (11%) 28 (11%) |
| Colombia | 16 | 17 | Benin | 5 | 5 |
| Costa Rica | 4 | 4 | Burkina Faso | 2 | 2 |
| Cuba | 4 | 5 | Cameroon | - | 1 |
| Dominican Republic | - | 1 | Cote d'Ivoire | 2 | 2 |
| Ecuador | 2 | 2 | Democratic Republic of Congo | - | 2 |
| Guatemala | - | 1 | Gabon | - | 2 |
| Guyana | 1 | 1 | Ghana | 1 | 1 |
| Mexico | 28 | 31 | Niger/Benin/Cote d'Ivoire | - | 1 |
| Panama | 3 | 6 | West/Central Africa | - | 1 |
| Peru | 1 | 1 | West & Central Africa | 10 | (4%) 17 (7%) |
| Trinidad & Tobago | - | 1 | | | |
| Venezuela | 6 | 5 | | | |
| Latin America & Caribbean | 120 | (46%) 141 (54%) | | | |

is considered on a case-by-case basis by the Executive Committee.

Research Location

Students from 47 countries have undertaken, or are undertaking, projects in 46 countries (Table 3). Most projects have been in the Latin America & Caribbean region (54%; Table 2), with 7 countries [Mexico (31), Argentina (27), Brazil (27), USA (21), Colombia (17), South Africa (17), Nepal (13)] making up 59% of projects to date. Excluding Europe, which has no range state for crocodilians, three regions had relatively low numbers of SRAS-funded projects - Australia & Oceania (10), East & Southeast Asia (17) and West & Central Africa (17).

Students

Most students carry out projects within their country/region of residence. Although only two (0.8%) projects have been based in Europe, this region has contributed a significant number of students who carry out projects in other regions (Table 2). Likewise, many US students have undertaken projects in other regions, particularly Latin America & Caribbean. As with research location, three regions had the lowest number of students originating from within the region - Australia & Oceania (6), East & Southeast Asia (9) and West & Central Africa (10).

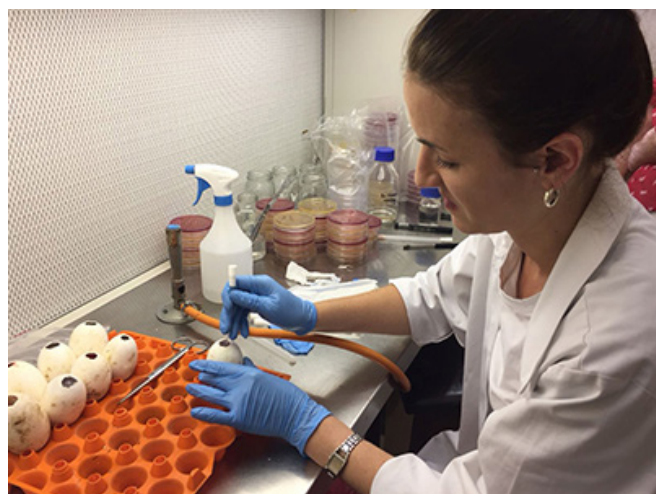


Figure 2. SRAS recipient, Antoinette Lensink, South Africa.



Figure 2. Latest SRAS recipient, Fortune Dhavana, South Africa.

To those who have been involved in crocodilian research, management and conservation over a long period of time, it is clear that there has been a significant increase in the numbers of women involved in both field and laboratory-based projects involving crocodilians (Figs. 1 and 2). Of the successful SRAS applicants, 55.6% were male and 44.4% were female (Table 3), which reflects to a large degree the gender of new participants in crocodilian research generally.

We are aware that there are projects being carried out without SRAS funding. For example, four students (3F, 1M) in Australia and two students (1F, 1M) in Malaysia and Indonesia, respectively, identified recently, have opted not to apply for funding. Two of these students were found to be unaware of the SRAS program, one student had funding from other sources, and the reasons for the other three students remain unknown.

Table 3. Gender of 250 successful SRAS applicants within each region. Nine applicants funded twice were only counted once.

| Region | Female | | Male | |
|---------------------------|--------|-----|------|-----|
| Australia & Oceania | 1 | 17% | 5 | 83% |
| South Asia & Iran | 7 | 30% | 16 | 70% |
| West & Central Africa | 3 | 30% | 7 | 70% |
| North America | 15 | 43% | 20 | 57% |
| Latin America & Caribbean | 55 | 47% | 61 | 53% |
| East & Southern Africa | 13 | 50% | 13 | 50% |
| Europe | 12 | 48% | 13 | 52% |
| East & Southeast Asia | 5 | 56% | 4 | 44% |
| All Regions | 111 | 44% | 139 | 56% |

Reporting

Reporting of completed SRAS projects is generally good, although it often requires the CSG Executive Officer to remind students of their obligations and chase up reports (Table 4). The reporting requirements are certainly not onerous, and there is no reason for non-compliance.

Table 4. Status of reporting by 259 SRAS applicants, 2009-September 2024.

| Period | Submitted Reports | Incomplete Studies | Reports Pending | Studies Ongoing |
|--------------|-------------------|--------------------|-----------------|-----------------|
| 2009-13 | 64 | - | - | - |
| 2014-18 | 78 | 2 | 9 | - |
| 2019-23 | 39 | - | 27 | 25 |
| Jan-Sep 2024 | 1 | - | - | 14 |
| All Years | 182 (70.3%) | 2 (0.8%) | 36 (13.9%) | 39 (15.0%) |

Crocodilian Species

The majority (96.1%) of SRAS applications deal with 1-2 species (Table 5). Two studies have dealt with 23-24 species, all/most of the crocodilian species recognised at the time, dealing with skull morphometrics (museum specimens) and vision (zoos/parks), respectively.

Six crocodilian species have each been involved in more than 20 projects, namely *Crocodylus acutus* (51), *Caiman latirostris* (44), *C. niloticus* (30), *Ca. crocodilus* (27), *C. moreletii* (23) and *Alligator mississippiensis* (22) (Table 6).

Table 5. Numbers of crocodilian species involved in SRAS-funded projects, 2009-September 2024.

| No. of Species in Study | No. of Projects | |
|-------------------------|-----------------|-------|
| 1 | 216 | 83.4% |
| 2 | 35 | 13.5% |
| 3 | 4 | 1.5% |
| 5 | 2 | 0.8% |
| 23 | 1 | 0.4% |
| 24 | 1 | 0.4% |
| 1-24 | 259 | 100% |

Table 6. Crocodilian species involved in 259 SRAS-funded projects, 2009-September 2024.

| Species | Single-Species Studies | Multi-Species Studies | Totals |
|-----------------------------------|------------------------|-----------------------|--------|
| <i>Crocodylus acutus</i> | 32 | 19 | 51 |
| <i>Caiman latirostris</i> | 37 | 8 | 45 |
| <i>Crocodylus niloticus</i> | 25 | 6 | 31 |
| <i>Caiman crocodilus</i> | 14 | 13 | 27 |
| <i>Crocodylus moreletii</i> | 13 | 10 | 23 |
| <i>Alligator mississippiensis</i> | 17 | 5 | 22 |
| <i>Crocodylus porosus</i> | 11 | 5 | 16 |
| <i>Crocodylus palustris</i> | 12 | 2 | 14 |
| <i>Gavialis gangeticus</i> | 11 | 2 | 13 |
| <i>Crocodylus suchus</i> | 6 | 6 | 12 |
| <i>Mecistops</i> spp. | 4 | 9 | 13 |
| <i>Melanosuchus niger</i> | 3 | 7 | 10 |
| <i>Caiman yacare</i> | 3 | 7 | 10 |
| <i>Osteolaemus</i> spp. | 2 | 9 | 11 |
| <i>Crocodylus mindorensis</i> | 3 | 5 | 8 |
| <i>Crocodylus intermedius</i> | 5 | 3 | 8 |
| <i>Paleosuchus palpebrosus</i> | 4 | 4 | 8 |
| <i>Alligator sinensis</i> | 4 | 2 | 6 |
| <i>Crocodylus rhombifer</i> | 2 | 4 | 6 |
| <i>Paleosuchus trigonatus</i> | 2 | 4 | 6 |
| <i>Tomistoma schlegelii</i> | 2 | 3 | 5 |
| <i>Crocodylus siamensis</i> | 3 | 2 | 5 |
| <i>Crocodylus johnstoni</i> | 1 | 2 | 3 |
| <i>Crocodylus novaeguineae</i> | 0 | 2 | 2 |
| All species | 216 | 139 | 355 |

CSG Membership

Of those SRAS recipients who submitted final reports, 104 (58%) are CSG members, two (1%) declined membership due to not continuing to work on crocodilians, and one (0.5%) is no longer a member of the group. There are also 14 (18%) SRAS recipients with on-going projects who were already CSG members. Currently, 11 (17%) of the 66 members of the CSG Steering Committee were previous recipients of SRAS funding.



Figure 3. SRAS recipient, Andres Rodriguez Cordero, Bolivia.

Conclusions

The SRAS program is considered to have been successful in achieving its goals, mainly assisting and/or encouraging students to undertake postgraduate research on crocodilians. To date, only two students (Ethiopia, Mexico) have indicated that they would not be able to complete their projects - a failure rate of 0.8%.

A review of the SRAS program by the Future Leaders Working Group was reported to the CSG Steering Committee in 2018, and most of the recommendations were adopted. These included: more explicit instructions for final reporting requirements; recommendations to future working meeting organizers to prioritize available travel funding for participation of SRAS awardees; policy of one award per degree be maintained; facilitate access to mentors for applicants; and, where applicable, CSG provide letters of endorsement that can be used for other funders.

Information and application forms are available on the CSG website, but it remains unclear as to how applicants initially hear about the program. A simple question on the application form could collate information on this issue. "Word of mouth" is clearly an important means of exposing potential students to the program, but other "advertising" strategies should also be investigated. With the development of a communication strategy now underway by the newly-

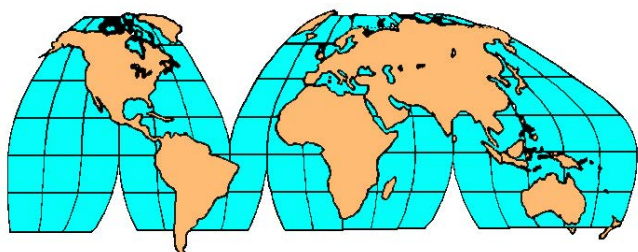
formed CSG Executive Advisory Group, consideration could be given to the SRAS program being more widely advertised across online platforms.

Europe has proven to be a significant source of students who carry out projects in other regions. Given that regions like West & Central Africa and East & Southeast Asia contain some of the most threatened crocodilian species, mechanisms to identify and engage students in those particular regions should be investigated.

The CSG extends its gratitude to donors who have supported the SRAS program financially over a long period of time. It also takes this opportunity to thank the many reviewers who have given their time and experience to the review of SRAS applications.

Charlie Manolis and Sally Isberg (csg@wmi.com.au).

Regional Reports



Latin America & the Caribbean

Dominican Republic

INITIATION OF HEAD-START PROGRAM AND ONGOING LIFE HISTORY RESEARCH FOR *CROCODYLUS ACUTUS* IN LAGO ENRIQUILLO, DOMINICAN REPUBLIC. The current population status of the American crocodile (*Crocodylus acutus*) in the Dominican Republic is considered “critically endangered”. Historically, Lago Enriquillo had the largest population of *C. acutus*, with over 500 breeding adults in the 1970s and early 1980s (Thorbjarnarson *et al.* 2006; Schubert and Santana 1996). The population saw major declines in the late 1980s and early 1990s, and in 1992 it was estimated that there were 160 adults and sub-adults in the lake (Schubert and Santana 1996).

A management plan was developed in 1992 and implemented in 1993, but was only short-term because a head-start program was seemingly successful, and the population appeared to increase (Schubert and Santana 1996). Ultimately, the population declined again due to illegal hunting, climatic stressors, and an overburden of predation by native and invasive species affecting successful nesting and survival (Greco *et al.* 2023). Results from a 2021 survey suggested that there were only 40-60 breeding adults remaining (Greco *et al.* 2023).

Key stakeholders from the preliminary research project in

2021, including the Dominican Ministry of Environment and Natural Resources (MMARN), SOH Conservación, Grupo Jaragua, the Dominican National Museum of Natural History (NMNH), Parque Zoológico Nacional (ZOODOM), Ecotopia, Maguey, the Crocodile Research Coalition (CRC), the Rosenblatt Lab at the University of North Florida, and Clemson University, decided that a head-start program would be beneficial to assist with the long-term recovery of the Lago Enriquillo population. Additionally, the team, led by Ramón Joel Espinal (MMARN), Marisa Tellez (CRC) and Bobby Greco (University of North Florida/Clemson University), planned to interact with communities to re-build pride and stewardship of crocodiles and their habitats, which can also have a positive umbrella effect on other local species.

This past May, the team initiated the head-start program for the Lago Enriquillo population of *C. acutus*. Between May and early-June, 25 newly-hatched hatchlings were collected from four nests between three nesting locations (La Charca, La Playita and KM5). Morphometrics were collected for each individual, a unique identification code was given via scute clipping, and the animals were released into concrete enclosures at La Azufrada, the Lago Enriquillo ranger station managed by MMARN. The enclosures were built in 2022 with funds donated by Sur Futuro, a local NGO and collaborator in the crocodile management project in the Dominican Republic. Of the 25 individuals, 15 will stay at this facility, and 10 will be transferred to ZOODOM in August for raising in their enclosures. Crocodiles will be maintained in these enclosures for two years before being released back in the lake. Monthly health assessments will be conducted to monitor the growth and health of the crocodiles.

At the same time that the 25 “head-start” hatchlings were captured, 93 other hatchlings from the same cohort were also captured. Morphometrics were collected and they were scute-clipped with a unique identification code before being released in the wild at same capture location. The team plans on comparing growth rates and health of the wild individuals to head-start individuals over the next two years. Data collected from this will be part of Bobby Greco’s dissertation project.

The team plans on using the head-start as an opportunity to start an internship program as an extension of the CRC internship program in Belize. Interns will have the unique opportunity to assist in the head-start program and other crocodile research at Lago Enriquillo, and provide them with valuable experience working on real-time wildlife management of a critically endangered population. Interns will also participate in community outreach and work with some of our partners in the Dominican Republic.

During the initiation of the head-start program, MMARN hosted a 4-day workshop at La Azufrada. In attendance were members of MENR, NMNH biologists and local NGOs, crocodile biologists from the El Salvador Environment Ministry (MARN), CRC biologists, and a PhD student from Clemson University (Fig. 1). During this program there were various presentations and workshops on research and

applied conservation techniques for crocodilians. There was also an excavation workshop where Juan Almonte, a NMNH paleobiologist, uncovered a complete skeleton of an adult *C. acutus* (Fig. 2).



Figure 1. Participants of the workshops on research and applied conservation techniques for crocodilians.

In addition to the head-start program, Bobby Greco, Ramon Joel Espinal, Andrys Gómez, Judá Isaí Martínez and the crocodile monitoring team comprised of MMARN rangers from Enriquillo Lake, will be conducting other life history research to better understand this unique population of *C. acutus*. Bobby Greco will be investigating different methods of population surveying and different population models to find out which are the most efficient for time, field effort, and estimation of population size. He will also be investigating home range selection of crocodiles, diet, and ecotoxicology of the Lago Enriquillo population. Ramon Joel Espinal's research focuses on nest and breeding ecology of the Lago Enriquillo crocodiles. This population displays many unique behaviours, such as nesting in substrate made of ancient coral.

Acknowledgements

Thanks to Sur Futuro, IUCN (SSC Edge Grant) and Jacksonville Zoo for funding to the head-start program, and to Programa Enlazando el Paisaje Centroamericano for funding to the workshop and the exchange.



Figure 2. Excavation of adult *C. acutus* skeleton by Juan Almonte.

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South Asia & Iran

India

FIFTY YEARS OF SUCCESSFUL IMPLEMENTATION OF ESTUARINE CROCODILE CONSERVATION AND RESEARCH PROGRAMME IN BHITARKANIKA NATIONAL PARK, ODISHA, INDIA: AN ANALYSIS. All three species of crocodile (Gharial, *Gavialis gangeticus*; Estuarine crocodile, *Crocodylus porosus*; Mugger crocodile, *Crocodylus palustris*) in India, including the State of Odisha, were on the verge of extinction by the 1970s (Bustard 1974), largely due to poaching and habitat loss (Acharjyo *et al.* 1996; Behura and Kar 1984; Bustard 1975). To address this situation, in 1975 the Government of India/FAO/UNDP Project “Crocodile Breeding and Management” was launched in different states.

The broad objectives of the project were:

- (a) To protect the remaining population of crocodilians in their natural habitat by creating sanctuaries and National Parks.
- (b) To rebuild natural populations quickly through ‘grow and release’ or ‘rear and release’ technique involving the following phases of operation:
 - Collection of eggs from natural nests as soon as possible after laying;
 - Artificial incubation of eggs under ideal conditions of temperature and humidity;
 - Hatching and rearing of crocodilians in ideal captive-husbandry conditions;
 - Marking and release of young crocodiles into protected areas; and,
 - Assessing the result of release along with protection of released crocodiles.
- (c) To promote captive breeding.
- (d) To carry out research to improve management. Some of the major research activities have been in the following directions:
 - Interpretation of various types of data collected during survey and census.
 - Determination of parameters for maximum success in egg collection, egg incubation, hatching, rearing and release, including husbandry aspects on feeding, food conversion and growth.
 - Study of habitat characteristics and population structure.
 - Study of behavioural biology including reproduction, thermoregulation, feeding, etc.
 - Study on human-crocodile interface.

The Estuarine crocodile conservation and research program was first implemented in Odisha by the Forest Department in early 1975. Technical expertise was provided by Dr.

Robert Bustard, the FAO/UNDP Chief Technical advisor to Government of India at the time (Daniel and Hussain 1975; Kar 1980, 1981). Bhitarkanika was chosen as the site for implementation of the project in the state of Odisha because it was known to contain a viable breeding population of *C. porosus* relative to other areas such as the Andamans and West Bengal Sundarbans.

Bhitarkanika is a deltaic area in undivided Cuttack district (now in Kendrapara district) of Odisha, formed by the alluvial deposits of tidal rivers such as the Brahmani, Baitarani and Dhamara (Fig. 1). To protect Estuarine crocodiles, as well as the threatened mangrove ecosystem, Bhitarkanika was designated as “Bhitarkanika Wildlife Sanctuary” (672 km²) on 17 April 1975, as per provisions of the *Wildlife (Protection) Act, 1972* (Fig. 2). The core area of the Bhitarkanika Wildlife Sanctuary was notified as “Bhitarkanika National Park” (145 km²) in 1998 (Behura and Kar 1984; Kar 1984). In 2002, Bhitarkanika Mangroves, a 650-km² area comprising Bhitarkanika National Park (145 km²), a portion of Gahirmatha Marine Sanctuary, and most of Bhitarkanika Wildlife Sanctuary, was declared a Ramsar site (Wetland of International Importance).



Figure 1. Typical mangrove habitat of Bhitarkanika National Park/Wildlife Sanctuary. Photograph: Sudhakar Kar.

There is no human habitation within Bhitarkanika National Park, which is a completely protected area under the *Wildlife (Protection) Act, 1972*. Elsewhere in Bhitarkanika Wildlife Sanctuary (ie outside the national park), there are numerous villages (310 villages and 145,301 people in 2011; Bannerjee 2023), schools and extensive areas of land under cultivation, and residents have free access to rivers for bathing, washing, fishing, etc.

Within the total area of Bhitarkanika Wildlife Sanctuary, there are some 460 km of tidal waterways (rivers, creeks, inlets) and 35 km of coastline. Of this, 160 km of riverine habitat and 30 km of coastline lie within Bhitarkanika National Park, and around 300 km of riverine habitat and 5 km of coastline falls outside the national park. All rivers drain into the Bay of Bengal (Fig. 2).

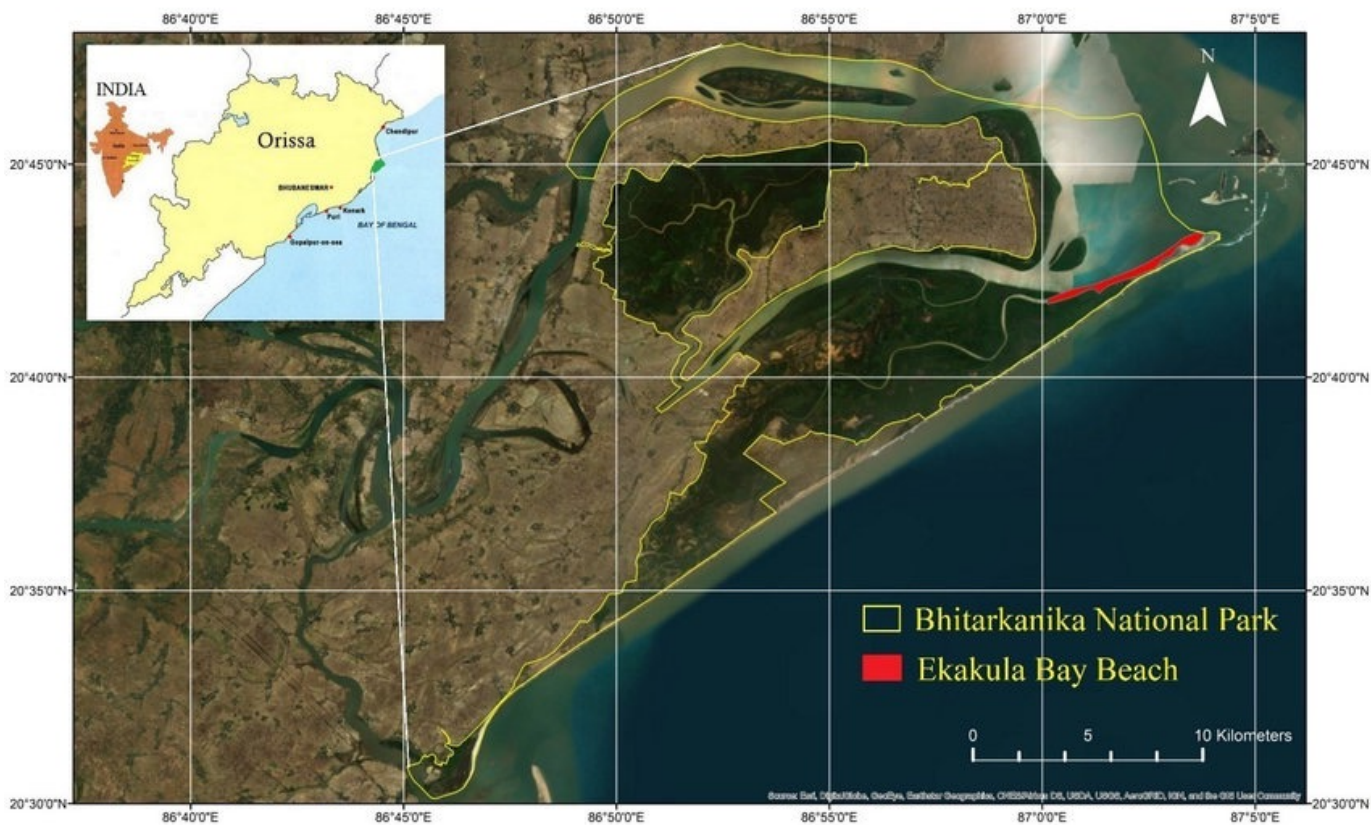
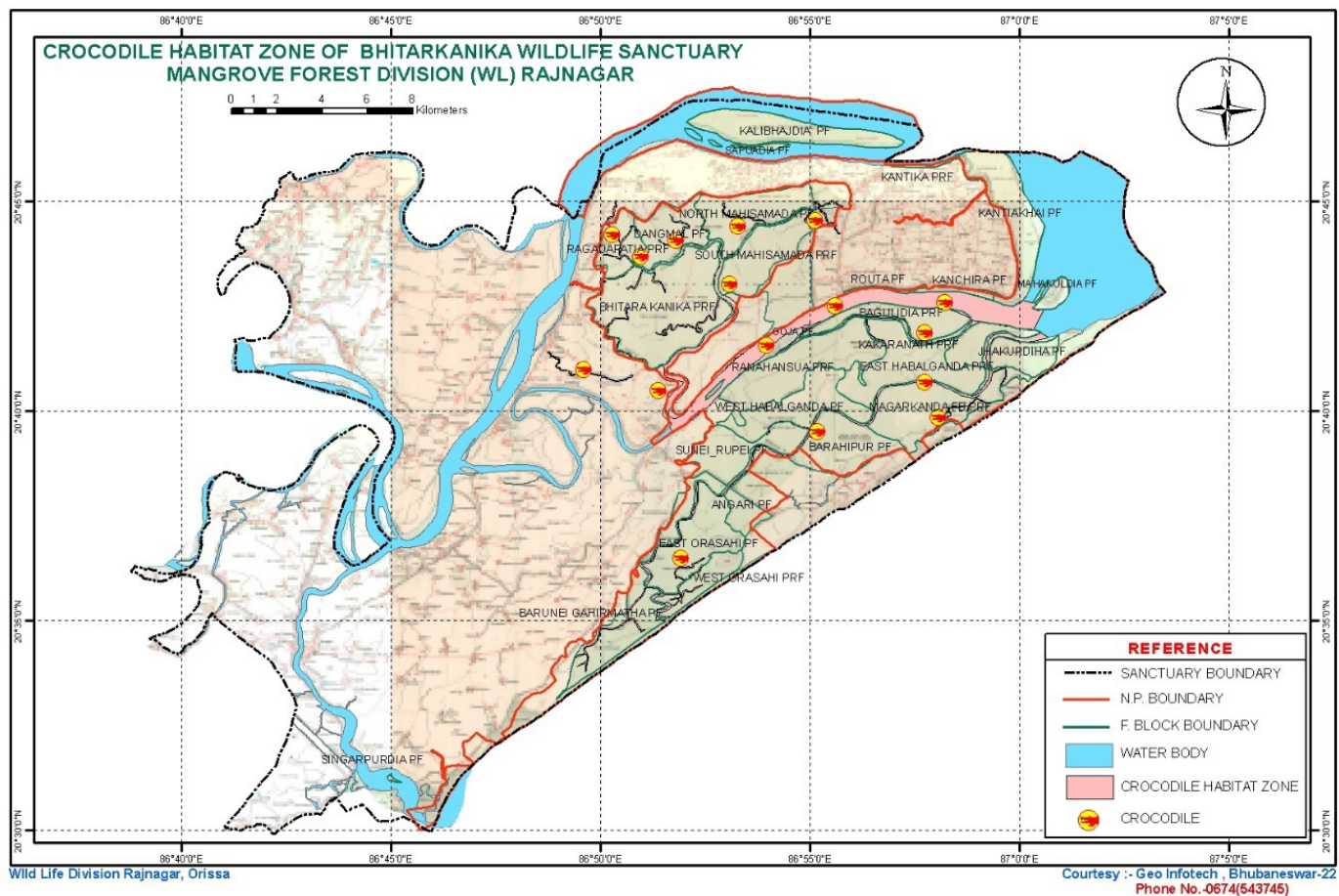


Figure 2. River and creek systems of Bhitarkanika National Park/Wildlife Sanctuary.

Table 1. Crocodile counts in Bhitarkanika National Park/ Wildlife Sanctuary, 1976-2024 (N= 37 surveys). H= hatchlings, Y= yearlings, J= juveniles, SA= sub-adults, A= adults, NH= total non-hatchling count, Total= total count (ie including hatchlings). *= yearlings counted as juveniles.

| Year | H | Y | J | SA | A | NH | Total |
|------|-----|-----|-----|-----|-----|------|-------|
| 1976 | 0 | * | 61 | 6 | 29 | 96 | 96 |
| 1985 | 0 | * | 118 | 13 | 34 | 165 | 165 |
| 1986 | 0 | * | 152 | 20 | 39 | 211 | 211 |
| 1989 | 0 | * | 213 | 32 | 58 | 303 | 303 |
| 1991 | 48 | * | 169 | 37 | 62 | 275 | 323 |
| 1993 | 115 | * | 179 | 53 | 67 | 299 | 414 |
| 1994 | 172 | * | 286 | 57 | 68 | 411 | 583 |
| 1995 | 208 | * | 323 | 60 | 69 | 452 | 660 |
| 1996 | 240 | 141 | 134 | 61 | 70 | 406 | 646 |
| 1997 | 191 | 184 | 151 | 63 | 71 | 469 | 660 |
| 1998 | 209 | 171 | 144 | 71 | 73 | 459 | 668 |
| 1999 | 198 | 166 | 152 | 82 | 74 | 474 | 672 |
| 2000 | 328 | 214 | 188 | 98 | 96 | 586 | 914 |
| 2001 | 391 | 258 | 246 | 105 | 98 | 707 | 1098 |
| 2002 | 467 | 327 | 282 | 117 | 137 | 863 | 1330 |
| 2003 | 404 | 360 | 181 | 121 | 162 | 824 | 1308 |
| 2004 | 531 | 306 | 210 | 127 | 184 | 827 | 1358 |
| 2005 | 681 | 290 | 169 | 107 | 207 | 773 | 1454 |
| 2006 | 657 | 283 | 197 | 122 | 203 | 805 | 1462 |
| 2007 | 503 | 368 | 259 | 135 | 232 | 994 | 1497 |
| 2008 | 538 | 343 | 231 | 143 | 261 | 978 | 1516 |
| 2009 | 538 | 375 | 264 | 148 | 271 | 1058 | 1596 |
| 2010 | 519 | 373 | 298 | 156 | 281 | 1108 | 1627 |
| 2011 | 531 | 377 | 304 | 166 | 292 | 1139 | 1670 |
| 2012 | 489 | 320 | 427 | 154 | 269 | 1170 | 1659 |
| 2013 | 486 | 356 | 396 | 128 | 295 | 1175 | 1661 |
| 2014 | 504 | 387 | 307 | 142 | 304 | 1340 | 1644 |
| 2015 | 511 | 380 | 317 | 149 | 308 | 1154 | 1665 |
| 2016 | 597 | 342 | 269 | 164 | 299 | 1074 | 1682 |
| 2017 | 608 | 334 | 266 | 172 | 302 | 1074 | 1682 |
| 2018 | 610 | 338 | 267 | 172 | 311 | 1088 | 1698 |
| 2019 | 619 | 349 | 273 | 178 | 325 | 1123 | 1742 |
| 2020 | 620 | 325 | 288 | 185 | 339 | 1137 | 1757 |
| 2021 | 593 | 367 | 320 | 152 | 336 | 1175 | 1768 |
| 2022 | 564 | 378 | 338 | 158 | 346 | 1220 | 1784 |
| 2023 | 569 | 388 | 325 | 166 | 345 | 1224 | 1793 |
| 2024 | 582 | 387 | 327 | 167 | 348 | 1229 | 1811 |

Surveys

The first population survey was undertaken in 1976 (Bustard 1975; Kanungo 1976), but regular surveys did not begin until 1985. Annual surveys have been undertaken since 1993 (see Table 1), and are carried out in December-January. Adults and sub-adults (>1.8 m) are counted during the day, and hatchlings (<0.6 m), yearlings (0.6-0.9 m) and juveniles (0.9<1.8 m) are mainly counted at night (Kar 2024a). Survey methodology has been fairly consistent over the 50 years of the program.

Surveys cover around 200 km of riverine habitats per year, comprising 160 km in Bhitarkanika National Park and 40 km outside the national park, but within Bhitarkanika Wildlife Sanctuary. The 40 km represents around 13% of the available riverine habitat outside the national park.

The first survey in 1976 resulted in a count of 96 non-hatchling crocodiles (Table 1; Kar 1978, 1980, 1981; Kar and Bustard 1989). Since then, the population has steadily increased, and over the last three years (2022-24) survey counts have been relatively stable, with an average of 1197 non-hatchlings counted (range 1220 to 1229) (Table 1; Fig. 3).

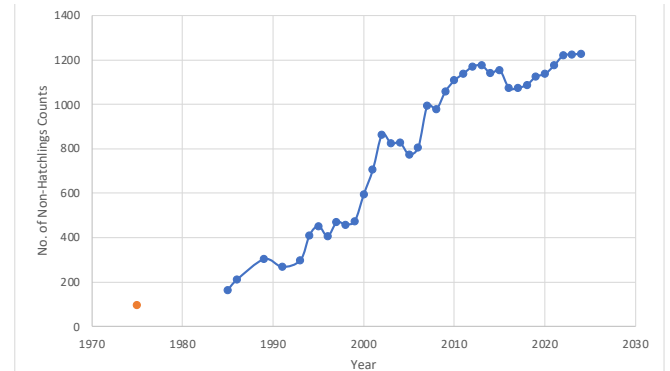


Figure 3. Numbers of non-hatchling *C. porosus* counted during surveys in Bhitarkanika Wildlife Sanctuary, 1976-2024 (see Table 1).

Nesting

Nest production in Bhitarkanika National Park, where the majority of nesting in Bhitarkanika Wildlife Sanctuary occurs (see Kar 2022), has increased significantly over time (Table 2; Fig. 4). Between 1975 and 1994, nesting effort was increasing slowly, but not significantly so ($r^2 = 0.08$, $p = 0.23$, $N = 20$); average of 4.9 nests located per year (range 1 to 10). As nest surveys were not conducted between 1995 and 2002, it is not known whether the increase up to 2003 occurred gradually or sharply after some point in time. Between 2003 and 2012, nesting also appeared stable ($r^2 = 0.17$, $p = 0.24$, $N = 10$), with an average of 48.8 nests located per year (range 44 to 54). Since 2013, nest numbers have increased significantly over time ($r^2 = 0.84$, $p = 0.0002$, $N = 10$), reaching 122 nests in 2022-23 (Table 2; Fig. 4), including nests laid by leucistic crocodiles (locally known as “Sankhua”; Kar 2015, 2022; see Fig. 6 and Front Cover).

Captive-reared female crocodiles released into the wild, and reaching maturity after 10-12 years of age, are considered to have contributed to the overall increase in nesting, particularly between 1995 and 2003 (Kar 1981, 2022; Fig. 4).

Mean clutch size over the last 5 years (2019-24) was around 30 eggs, due in part to a high proportion of young mature female crocodiles in the population. Young females lay low numbers of eggs, whereas large, old females average around 45 eggs per clutch.

Table 2. Numbers of *C. porosus* nests located in Bhitarkanika National Park. Between 1995 and 2002, nest surveys and large-scale egg collection ceased (see text).

| Year | No. of Nests | Year | No. of Nests |
|------|--------------|------|--------------|
| 1975 | 1 | 2003 | 49 |
| 1976 | 6 | 2004 | 53 |
| 1977 | 5 | 2005 | 47 |
| 1978 | 4 | 2006 | 46 |
| 1979 | 5 | 2007 | 54 |
| 1980 | 3 | 2008 | 49 |
| 1981 | 5 | 2009 | 51 |
| 1982 | 4 | 2010 | 50 |
| 1983 | 4 | 2011 | 44 |
| 1984 | 5 | 2012 | 45 |
| 1985 | 10 | 2013 | 56 |
| 1986 | 6 | 2014 | 61 |
| 1987 | 5 | 2015 | 63 |
| 1988 | 2 | 2016 | 69 |
| 1989 | 3 | 2018 | 101 |
| 1990 | 5 | 2019 | 103 |
| 1991 | 9 | 2020 | 103 |
| 1992 | 3 | 2021 | 84 |
| 1993 | 8 | 2022 | 122 |
| 1994 | 5 | 2023 | 122 |

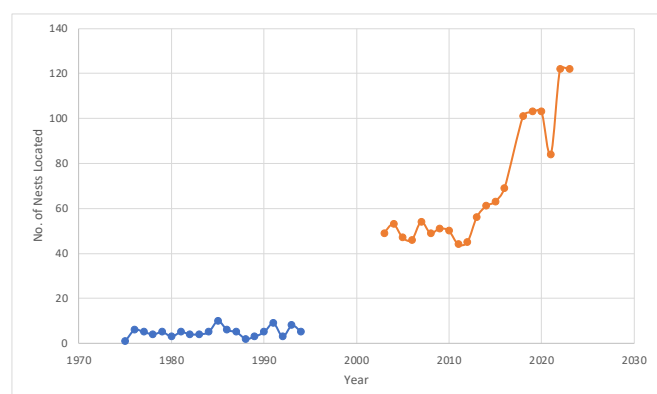


Figure 4. Numbers of *C. porosus* nests located during nest surveys in Bhitarkanika National Park. No surveys were carried out in 1995-2002.



Figure 5. Female *C. porosus* actively guarding her nest situated in *Phoenix paludosa* habitat. Photograph: Sudhakar Kar.

Table 3. Mean size structure of non-hatchling *C. porosus* sighted during surveys. N= number of years/surveys.

| Period | N | Juveniles (%) | Sub-adults (%) | Adults (%) |
|---------|---|---------------|----------------|------------|
| 1975-80 | 1 | 63.5 | 6.3 | 30.2 |
| 1981-85 | 1 | 71.5 | 7.9 | 20.6 |
| 1986-90 | 2 | 71.2 | 10.0 | 18.8 |
| 1991-95 | 4 | 66.0 | 14.7 | 19.3 |
| 1996-00 | 5 | 68.5 | 15.5 | 16.0 |
| 2001-05 | 5 | 65.9 | 14.5 | 19.7 |
| 2006-10 | 5 | 60.5 | 14.3 | 25.2 |
| 2011-15 | 5 | 61.8 | 12.8 | 25.4 |
| 2016-20 | 5 | 56.4 | 15.5 | 28.1 |
| 2021-24 | 4 | 58.4 | 13.3 | 28.4 |

Nesting in Bhitarkanika National Park typically occurs in the last week of May and first two weeks of June (Fig. 5), and nest surveys were undertaken from the third week of June to mid-July. Attempts are made to locate as many nests as possible, but due to habitat conditions, around 85-90% of the nests that are present are estimated to be located.

Since 1975, 6482 *C. porosus* eggs from 142 nests have been collected from Bhitarkanika National Park, with the majority being collected in 1975-95 (4348 eggs, 96 nests). Large-scale collection ceased after 1995, and only low numbers (<1-2 nests) have been collected annually since that time [1996-2010 (1451 eggs, 32 nests), 2011-24 (673 eggs, 14 nests)]. Eggs are artificially incubated by simulating natural conditions (Fig. 6), with resulting hatchlings being reared in pools at Dangmal Crocodile Research Centre (situated within Bhitarkanika National Park).



Figure 6. Hatchlings emerging from artificial nests after around 75 days of incubation. Photograph: Sudhakar Kar.

Water monitors (*Varanus salvator*) and wild pigs (*Sus scrofa*) are known predators on eggs, and flooding contributes to egg mortality. Although not quantified precisely, it is estimated that around 40% of eggs hatch successfully on a “normal” year.

Size structure

Given that crocodiles are categorised in very broad size classes, it is not possible to discern changes in size structure

over time in detail. Also, it is important to note that the population has been reinforced through the release of large numbers of captive-raised juveniles. Nonetheless, it is clear that since 1985 the proportion of adults in the non-hatchling portion of the sighted population, has increased (Table 3), which reflects a population that has not yet stabilised in terms of size structure. It is expected that this trend will continue.

Bhitarkanika has at least 23 crocodiles of 4.8-5.5 m TL, 6 crocodiles of 5.5-6.0 m TL and 4 crocodiles >6.1 m TL.

Population size

The *C. porosus* population in Bhitarkanika Wildlife Sanctuary has clearly increased over the 50-year period since 1975. This increase has been due to natural nesting, by wild and released females, as well as by the release of captive-raised juvenile crocodiles into the area. Between 1977 and March 2024, 3008 captive-reared juveniles (mostly 0.9-1.2 m TL) were released in phases into suitable creeks and rivers (eg creeks away from human habitation; Kar 1981, 1990, 2013; Kar and Bustard 1991). The first release (15 crocodiles) occurred in the winter of 1977, and continued in 63 additional phases up to winter of 2024 (average of 47 crocodiles/phase; range 4 to 173; Table 4, Fig. 7). Around 95% of crocodile sightings in the 2024 survey occurred in Bhitarkanika National Park (Kar 2024a).

Table 4. Numbers of captive-raised *C. porosus* released into Bhitarkanika National Park, 1977-2024 (see Fig. 7).

| Year | N | Year | N | Year | N |
|------|-----|------|-----|------|-----|
| 1977 | 15 | 1993 | 120 | 2010 | 196 |
| 1978 | 80 | 1994 | 60 | 2011 | 73 |
| 1980 | 30 | 1995 | 70 | 2012 | 50 |
| 1981 | 30 | 1996 | 40 | 2013 | 15 |
| 1983 | 75 | 1997 | 277 | 2014 | 45 |
| 1984 | 50 | 1999 | 11 | 2015 | 50 |
| 1985 | 100 | 2000 | 45 | 2016 | 50 |
| 1986 | 220 | 2001 | 18 | 2018 | 31 |
| 1987 | 355 | 2002 | 20 | 2019 | 30 |
| 1988 | 68 | 2005 | 26 | 2020 | 38 |
| 1989 | 77 | 2006 | 42 | 2021 | 32 |
| 1990 | 14 | 2007 | 69 | 2022 | 36 |
| 1991 | 23 | 2008 | 72 | 2023 | 61 |
| 1992 | 70 | 2009 | 187 | 2024 | 37 |

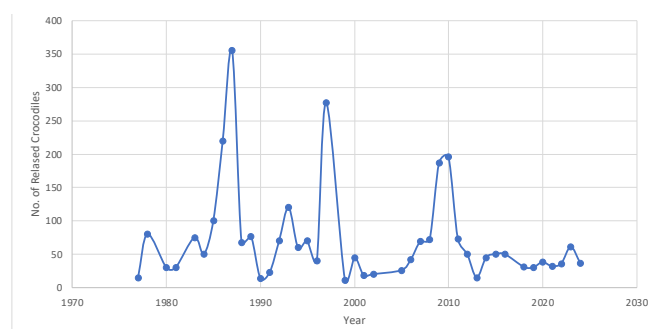


Figure 7. Numbers of captive-raised *C. porosus* released in Bhitarkanika National Park, 1977-2024 (see Table 4).

Over the last 20 years, the population has increased at a mean rate of around 2.45% per annum. Ongoing monitoring will quantify the extent to which the population stabilises in terms of size (number of crocodiles), and the extent to which size structure (average size of crocodile) changes. Releases of large numbers of captive-raised crocodiles into Bhitarkanika National Park were discontinued in 2010 (Kar 2015), and low numbers have been released annually since then (Table 4).

No attempts were made to assess the survivorship of released crocodiles over time, but clearly there has been mortality (natural and anthropogenic), as well as movement out of the area. For example, marked (released) crocodiles have been detected outside of Bhitarkanika Wildlife Sanctuary, and some crocodiles are known to have drowned in fishing nets. Crocodiles may also be swept out to sea during monsoonal high tides and flooding.

With increasing numbers of large (adult) *C. porosus* in the population (Tables 1 and 3), the mortality on smaller crocodiles was expected to increase, due to social interactions with larger crocodiles (Webb and Manolis 1992). Interestingly, the first cases of predation of small crocodiles by large crocodiles were observed in 2022 (Kar 2024b).

The number of hatchlings sighted in one year, relative to the number of yearlings sighted the following year provides an estimate of “retention rate” of hatchlings sighted into the yearling age class. Since 1996, when sightings of yearlings were separated from juveniles (see Table 1), retention rate has decreased, from around 0.79 in 1996-2005 to 0.60 in 2016-24 (Table 5). That is, a lower proportion of hatchlings sighted are being recruited into the yearling size/age class. Webb *et al.* (1984) reported an average retention rate of 0.81 for *C. porosus* in northern Australia in the early 1980s, when that population was considered to have recovered to around 40-50% of historical levels.

Table 5. Mean retention rates (RR) for hatchling *C. porosus* entering the yearling class the following year. SD= standard deviation; N= number of years.

| Period | Mean RR | SD | N |
|-----------|---------|-------|---|
| 1996-2000 | 0.84 | 0.154 | 5 |
| 2001-2005 | 0.74 | 0.112 | 5 |
| 2006-2010 | 0.61 | 0.122 | 5 |
| 2011-2015 | 0.72 | 0.072 | 5 |
| 2016-2020 | 0.58 | 0.055 | 5 |
| 2021-2024 | 0.62 | 0.068 | 4 |

By the time of annual survey, typically undertaken in January, hatchlings would be around 5 months of age. Mortality between hatching and 5 months of age has not been quantified, but is estimated to be around 50%. Thus, the overall loss of hatchlings to one year of age is estimated to be around 70% in a “normal” year.

It is difficult to estimate absolute population size in the

absence of reliable correction factors to convert daytime and spotlight counts to absolute numbers. Using correction factors used in northern Australia for spotlight surveys in tidal rivers (Bayliss *et al.* 1986; Webb *et al.* 1986), estimated correction factors for day-time surveys, and taking into account habitats that were not surveyed, the population would be estimated to be around 2320 non-hatchlings and 2900 individuals (ie including hatchlings) in Bhitarkanika Wildlife Sanctuary. However, caution should be exercised in assessing these estimates given the variables that potentially impact on such calculations (eg levels of wariness, differences in survey methodology, anthropogenic disturbance), and particularly the lack of information on applicable correction factors to correct relative counts to absolute counts.

Nonetheless, based on these population estimates, and taking into account that 95.4% of counts were in Bhitarkanika National Park in 2024 (Kar 2024a), mean density there would be estimated as 9.9 non-hatchlings/km and 13.5 crocodiles/km. Outside of Bhitarkanika National Park, mean density would be estimated as 2.4 non-hatchlings/km and 2.5 crocodiles/km.

Densities are not homogeneous, with highest densities being in the main Bhitarkanika River from Kholā to Pathasala, Thanapati Creek, Mahinsamada Creek, Suajore Creek, Baunsagada Creek and Kalibhanjadia. Areas where nesting occurs [ie with good nesting habitat, such as Kharakhari (*Acrostichum aureum*) and Hental (*Phoenix paludosa*)] have a higher density of crocodiles of all age/size classes.

Human-crocodile conflict

Studies on man-crocodile interface in Bhitarkanika National Park/Wildlife Sanctuary have been conducted to prevent human casualties. The Mangrove Wildlife Division of the state Forest Department is very much concerned, and taking all possible steps, to prevent human-crocodile conflict (HCC). These are important activities which have significance for the future management and conservation of the species and the mangrove ecosystems.

HCC occurs both within and outside Bhitarkanika National Park, with the majority of incidents in the latter. Attacks within Bhitarkanika National Park typically involve people residing adjacent to the national park, who sometimes fish illegally and/or enter to collect grass for basket-making. Large crocodiles moving out of Bhitarkanika National Park at different times of the year (eg upstream movement during the monsoon season) also pose a significant threat to people living outside the national park, and who rely on the river for daily activities (eg bathing, washing, fishing, etc.).

Kar and Bustard (1983) reported an average of 0.4 attacks/year for the period 1971-80, which increased significantly to 1.6 attacks/year for 1981-2015, and to 3.2 attacks/year for 2016-August 2024 (S. Kar, unpublished data).

Awareness programs have been implemented to deter villagers entering rivers during the monsoon period, and

150 bathing ghats [= barricades or “crocodile exclusion enclosures” (CSG 2024); 1-2 per village] have been provided by the Forest (Wildlife) Department to improve safety for villagers. As bamboo and wooden poles do not last very long, ghat construction now involves the use of steel posts cast in PVC pipes with concrete, and plastic-coated chain mesh. The ghats are very effective, and the majority of villagers use them (Fig. 8).



Figure 8. Ghat at river bank to protect villagers from crocodiles. Photograph: Bijay Kumar Patra.

Prior to declaration of the National Park and Wildlife Sanctuary, much of the mangrove forest in the area had been over-exploited, resulting in a loss of river bank vegetation, and allowing easy access by people and cattle to the rivers. Establishment of a minimum 50-m strip of mangroves along all creek and river banks in and outside Bhitarkanika National Park/Wildlife Sanctuary is being implemented by the Forest (Wildlife) Department, as a measure to mitigate HCC and check bank erosion.

Threats

The main threats to crocodiles in Bhitarkanika Wildlife Sanctuary (including Bhitarkanika National Park) are:

- illegal fishing in rivers and creeks outside the Bhitarkanika National Park;
- aquaculture activities inside and outside the Bhitarkanika National Park;
- illegal collection of wood and forest products; and,
- cattle grazing outside the Bhitarkanika National Park.

Conclusions

The primary objective of the ongoing crocodile project is to rebuild the wild *C. porosus* population through restocking of Bhitarkanika National Park with captive-reared crocodiles. The extent to which this is achieved will be assessed through ongoing monitoring of the crocodile population and associated research activities (eg egg collection, egg incubation, husbandry, etc.; Kar 1982; Singh and Kar 2021; Singh *et al.* 1984).

Training is considered an important element of the program, and has been provided to all field staff employed in the project to help them to discharge their duties efficiently. In addition,

local people have been engaged in crocodile husbandry work, watch and ward, tourism, habitat development and other associated activities.

As in other countries with other species, crocodilian species have demonstrated their ability to recover quickly if habitats are relatively intact and some level of protection is in place. Bhitarkanika National Park is an example of this, and the future of its *C. porosus* population will be secured with continued protection and restoration of the habitats.

Acknowledgments

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SEVERAL MUGGER CROCODILES BURN AND DIE IN WETLAND FIRE. On World Crocodile Day, celebrated on 17 June 2024, two NGOs were busy rescuing Mugger crocodiles (*Crocodylus palustris*) from a fire within Pariej Wetland, Anand, Gujarat, India (Fig. 1). This incident is the first record of mortality of Muggers as a result of fire.

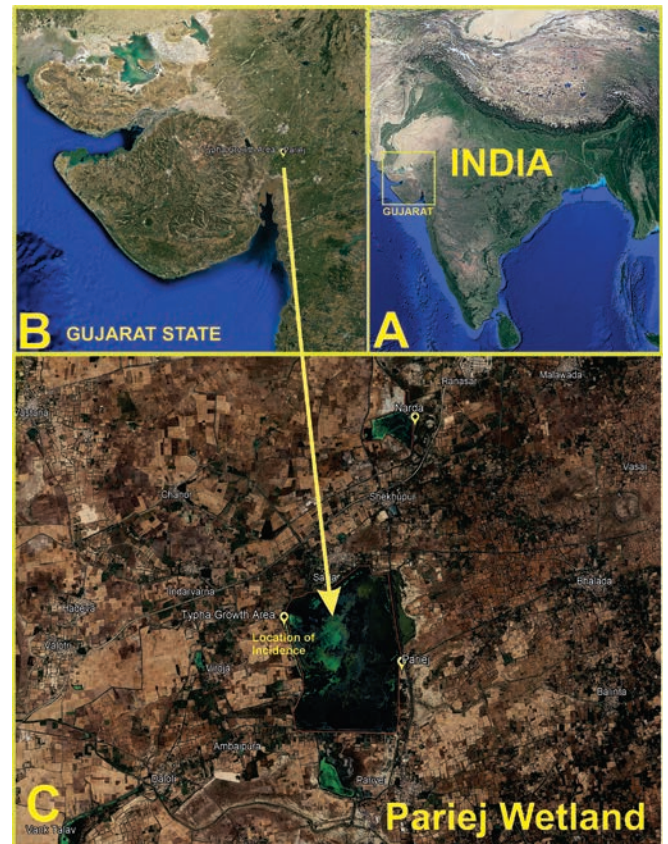


Figure 1. Location of fire in Pariej Wetland.

On 17 June 2024, social media reported a large burned Mugger emerging from a fire (Fig. 2) in pockets of *Typha* grass in Pariej Wetland (Fig. 1). On hearing that news, a group of volunteers from two local NGOs (Animal Saving Group and Voluntary Nature Conservancy, Vidyanagar) immediately rushed to the site.



Figure 2. Mugger emerging from fire at Pariej Wetland. Photograph: Voluntary Nature Conservancy.

A rescue operation, a testament to the power of community involvement in conservation, was carried out over four days by

dozens of volunteers and local staff of the Forest Department, who worked tirelessly to retrieve 15 Muggers from the fires (Fig. 3). Of these, 11 Muggers were saved after treatment (Fig. 4), and released into a nearby water body about 2.5 km north, at Narda (22°35'13.72"N, 72°37'24.52"E; Fig. 1). The remaining four sub-adult Muggers, as well as a number of Indian Flap-shell Turtles (*Lissemys punctata*), had perished (Fig. 5).



Figure 3. Large Mugger rescued from Pariej Wetland. Photograph: Voluntary Nature Conservancy.



Figure 4. Injured Mugger under treatment at Pariej Eco-Tourism Site, Pariej Wetland. Photograph: Voluntary Nature Conservancy.



Figure 5. Dead adult Mugger due to fire at Pariej Wetland. Photograph: Voluntary Nature Conservancy.

Pariej Wetland (22°31'39.84"N to 22°33'47.07"N and 72°36'24.19"E to 72°37'31.73"E) is one of the largest man-made water bodies in the Matar, Kheda district, with an area of 445 ha (4.45 km²) and a maximum depth of 1.8 m. The low-lying saline area of this region of Matar tehsil was converted into a reservoir by the construction of a 5-m tall earthen wall. Pariej Wetland is connected by a sub-minor canal to the Mahi

Irrigation Canal System, and water is used for both irrigation and drinking purposes. There is saline habitat on the eastern and southern sides of the wetland, whereas the remaining two boundaries share agricultural fields.

Prior to 2024, the wetland was full of aquatic vegetation, the most dominant hydrophytic emergent vegetation on surrounding fringes being Cattail (*Typha angustata*). Hydrophytes like Water lily (*Nymphaea* sp.), Indian lotus (*Nelumbo nucifera*), Water hyacinth (*Eichhornia crassipes*) and Water spinach (*Ipomoea aquatica*) covered the water surface almost entirely. There was excessive growth of submerged vegetation supported by various wildlife, including many species of migratory waterfowl and birds, and a few species of aquatic reptile.

However, misfortune for the wetland started in January 2024, when the state Water and Irrigation Department began de-silting and dredging Pariej Wetland without regard to concerns of other state forest and environmental departments or groups. By February, the wetland had been drained (Ghai 2024) and deepened by excavating earth from the reservoir, using dozens of excavators, bulldozers and other machines. The wetland environment became extensive areas of dry ground surrounding pockets of tall *Typha* sp. (Tatu 2024).

Most living organisms disappeared from the wetland (eg birds). However, aquatic reptiles like Muggers and turtles stayed beneath the large (5 km²) remaining pockets of 2-m *Typha* or in burrows on the western boundary of the wetland, in water seepage areas. Finally, on 16 June 2024, the entire *Typha* habitat was set alight by some culprit, resulting in this tragedy.

There are few reports of crocodilian mortality as a result fire, although it has no doubt occurred from time to time. Webb and Manolis (1989) refer to a relocated Saltwater crocodile (*C. porosus*) walking overland and being caught in a bushfire and died as a result of the burns sustained. And fire is certainly known to affect crocodilian habitats.

Acknowledgments

We thank Rahul Solanki (President), and the Volunteers of Nature Help Foundation. Special thanks and support of Dhaval Patel (President), Lucky Singh, and Piyush Parmar, Voluntary Nature Conservancy, Vallabh Vidyanagar, Anand, Gujarat, India. Thanks to local forest staff for support and help in rescuing Muggers.

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ILLEGAL TRADE IN GHARIAL IN NORTHERN INDIA. Here, we report on a case of attempted illegal trade of Gharial (*Gavialis gangeticus*) in northern India in the last week of June 2024. Such large-scale poaching has not been reported previously, with the confiscation of 130 hatchling Gharial and 29 Red-crowned Roofed turtles (*Batagur kachuga*). A previous case involved 7 hatchling Gharial being confiscated in Thailand, in 2011 (TRAFFIC 2011).

Two people were intercepted with the endangered reptiles, at Prayagraj Station (Uttar Pradesh), from a train bound for West Bengal. The authors were asked to assist with the identification and care of the confiscated reptiles.



Figure 1. Confiscated Gharial hatchlings.

The Gharials had been packed in transparent perforated plastic containers (30 x 25 x 12 cm), the bottoms of which were lined with pieces of wet gunny sack (Fig. 1). A sample (10%) of the animals were weighed and measured; mean Total Length for Gharials was 43.37 cm and mean Body Weight was 105 g, which indicated they had hatched in the current season (generally late-May hatching).

The reptiles were translocated to the state-run Kukrail Gharial Rehabilitation Centre (Lucknow) within 24 hours of confiscation. Fortunately, swift action ensured no mortality. The Gharials are currently under quarantine, and will be maintained separately until their release back to the wild. It is likely that they will be integrated into the “head-starting” program of the centre, which was established in 1975 to assist efforts to recover the wild Gharial population.

It is recommended that Chambal Sanctuary Administration from all three states - Rajasthan, Madhya Pradesh and Uttar Pradesh - increase patrolling specially along the documented Gharial nesting sites during the hatching season (May) until the hatchlings fully disperse (August).

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Editor’s Note: An official report on this confiscation has yet to be released to the media. Thus, in view of potential legal proceedings underway, some details on this case provided by the authors were not included in the article.

Australia & Oceania

Australia

“CrocBSI” - A SIMPLE VISUAL CROCODILIAN BODY SCORING METHOD. Being able to visually and quickly assess and communicate the body score (BS) of crocodilians is fundamentally important for crocodilian managers and veterinarians. BS, also referred to as “body condition score”, is an indication of an animal’s fitness based on the amount of fat and muscle tissue located at specific points on the body, reflective of its current nutritional and health status as well as its adaption to the environment. Being able to detect changes in BS early allows prompt management, and where necessary, veterinary assistance to uphold the highest crocodilian welfare standards.

Crocodilians store fat predominantly in their jowls (neck), anterior tail, and within the abdominal cavity (fat body and mesenteric fat; Huchzermeyer 2003). As with all vertebrates, the amount of muscle mass and fat stored is proportional to the cumulative amount of energy being consumed (type and quantity of food) and the energy being expended (growth, maintenance, exercise and disease state). When a crocodilian ceases to eat due to food restriction, inappropriate husbandry or disease, it begins to utilise its fat stores to meet its energy requirements. In severe cases, muscle catabolism may also occur. Conversely, if a crocodilian is fed to excess without proportionate energy expenditure, fat is accumulated in these reserve areas.

There is already a substantial body of literature on crocodilian body scores. Most require the physical handling of the crocodilian to measure various morphometric qualities (length and weight), and then applying mathematical formulae to determine a score such as the Fulton index (K: Mazzotti *et al.* 2012; Zweig *et al.* 2014; Brandt *et al.* 2016; Ojeda-Adame *et al.* 2020), relative condition index (Kn) and scaled mass index (SMI: Ojeda-Adame *et al.* 2020). Capturing and handling

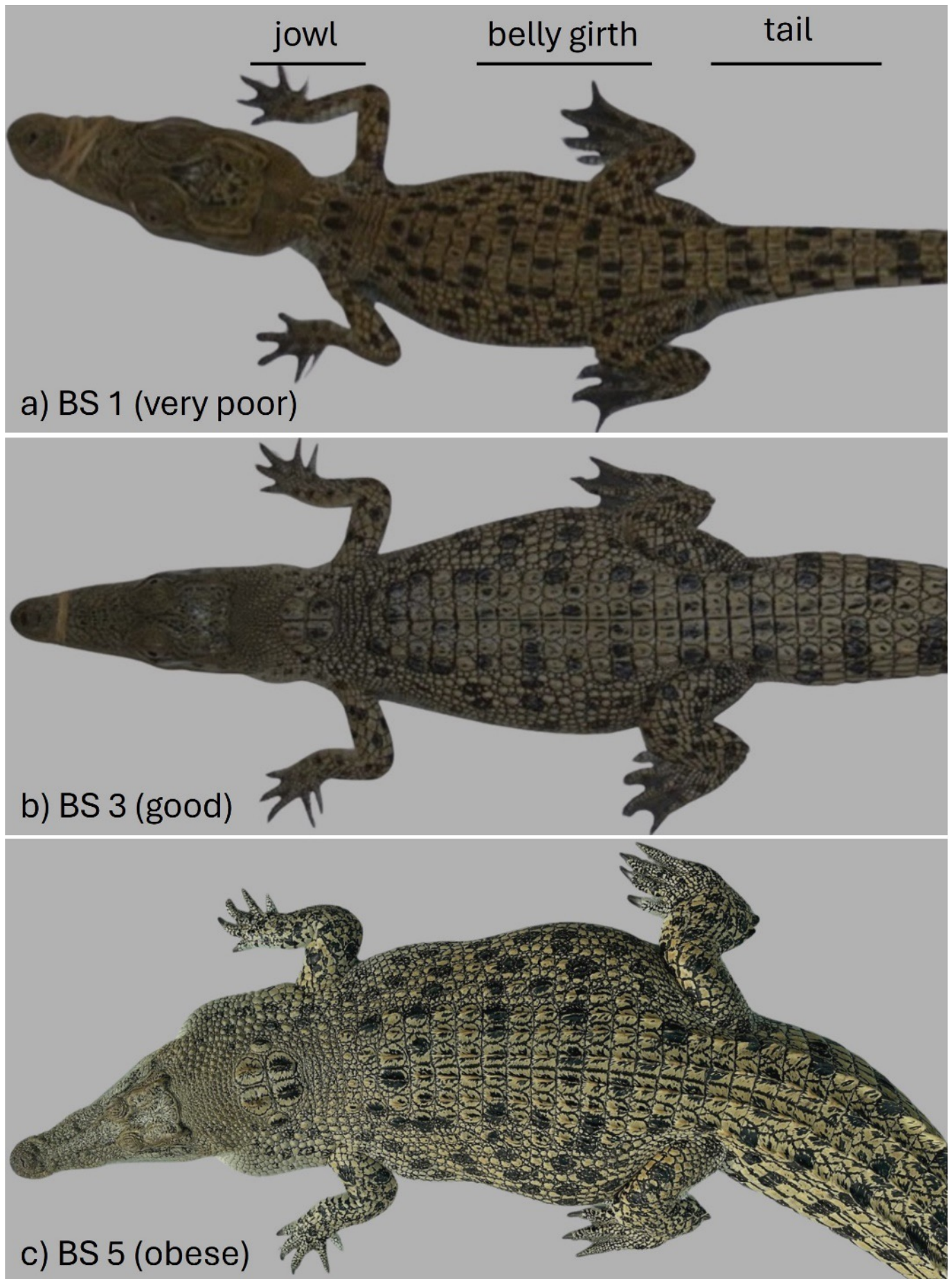


Figure 1. Examples of Saltwater crocodiles (*Crocodylus porosus*) displaying body scores of a) BS 1 (very poor), b) BS 3 (good) and c) BS 5 (obese), using the CrocBSI scoring system.

Table 1. Crocodilian Body Score Index (CrocBSI) categories, descriptions and possible actions.

| Score | Body Condition | Description | Action |
|-------|----------------|---|--|
| BS 1 | Very poor | <ul style="list-style-type: none"> · No muscle or fat around the jowls or base of tail (wasting) · Neck tendons visible · Head can be disproportionately larger than body · Belly is sunken (lack of food intake) · Spine may be visible but not always | <p>Probable causes:</p> <ul style="list-style-type: none"> · runtting in young stock · severe undernourishment · poor husbandry and management <p>Minimise stress and remove from dominant animals however, unlikely to recover at this stage. Euthanasia may be required</p> |
| BS 2 | Poor | <ul style="list-style-type: none"> · Slight muscle tone and fat reserves around neck and base of tail · Animal is eating, appears bright and alert (responsive to stimuli) | <ul style="list-style-type: none"> · Review management and husbandry (food (quality and quantity), temperature profile, water quality, hygiene and disease management, provision of hides) to minimise stress · Veterinary advice may be required · Remove from dominant animals · Target feed |
| BS 3 | Good | <ul style="list-style-type: none"> · Slight bulge of fat around jowls · Outwardly bowed tail indicating adequate muscle tone and fat reserves · Animal obviously eating, with stomach bulge also indicating reserves within internal fat body on non-feed days | <ul style="list-style-type: none"> · No action required · Monitoring and early detection of body score changes is crucial to ensuring that crocodilian does not drop to a BS 2 |
| BS 4 | Very Good | <ul style="list-style-type: none"> · Exaggeration of 3 above | <ul style="list-style-type: none"> · No action required · Consider restricting food but not essential |
| BS 5 | Obese | <ul style="list-style-type: none"> · Excessive fat reserves at jowls and tail as well as always looking enlarged around the belly area. Torso may even appear “rectangular” · Stretching of inter-scalar area indicates overly fat crocodilian · Often a captive problem from being over-fed without proportional energy expenditure to maintain weight. | <ul style="list-style-type: none"> · Restrict food intake through either reducing portions offered and/or feeding frequency · Encourage exercise or environmental enrichment where appropriate (e.g. swimming to the other side of water for food, reward for voice cue etc.) · Offer alternative low nutritional food stuffs such as apples soaked in myoglobulin, empty sausage casings |

of crocodilians has been well documented to invoke stress responses (eg lactic acid, glucose, corticosterone, etc.: Lance and Elsey 1999; Franklin *et al.* 2003; Finger *et al.* 2015, 2018; Isberg *et al.* 2018) that can have downstream consequences on other functions such as resumption of feeding, posturing and thermoregulation behaviours and immunocompetence, which may be counter to the primary purpose of assessing the BS in the first instance. Furthermore, weighing crocodilians can be inaccurate depending on the time since the crocodilian’s last meal and the amount eaten, as well as, particularly for larger specimens, being technically and logistically challenging and

leading to large margins of error.

Squires *et al.* (2021) were the first to propose a visual assessment tool to categorise crocodilian BS using the limbs, jowls, spinal column and jowls, but only classified very skinny/emaciated (1) to normal (3) body scores. Terry (2021) extended on this using the head, neck, forelimbs, torso, hindlimbs and tail, creating categories of 1 (emaciated) to 9 (obese). This was presented in a complex 9 row x 9 column table that is difficult to read and hard to discuss in field settings when determining possible management solutions

where issues are identified. A remote body condition score system (1-5) has also been proposed by Viljoen *et al.* (2023) by measuring belly width and total length from photographs taken using uncrewed aerial vehicles (drones). This method required the animal to be separate from others, motionless, and on a dry emergent surface which limits its utility in most situations.

Instead, I have been successfully using CrocBSI (Crocodilian Body Score Index), a simple (1-5) visual scoring index, for many years now, using the three predominant fat storage regions - the jowls, tail and belly girth. It is essentially a refinement of those categories described by Terry (2021), but removes the anatomical areas that are less indicative of fat storage. As such, this method has been widely applied to all crocodilians, regardless of species, age, size or location (captive or wild), at both the individual and herd/population level, making its use universally applicable. It allows easy communication between the crocodilian keepers and myself, even remotely, to discuss appropriate intervention strategies as required. CrocBSI has been accepted by multiple animal ethics committees for use during research involving crocodilians and is now integrated into multiple crocodilian welfare management programs. Descriptions of the categories are in Table 1.

CrocBSI is not too dissimilar to the 1-5 visual scoring system proposed by Ojeda-Adame *et al.* (2020), but they limited their categorisation to observations of the neck and thorax regions alone. In my experience, a change in these areas occurs after animals cease eating (reduced belly girth) and tail fat catabolism has been actuated for some time prior.

How to use CrocBSI

The majority of wild and captive crocodilians (Ojeda-Adame *et al.* 2020) will be in BS 3 (good), with sufficient fat stores, such that slight bulges in the jowl area and tail, just posterior to the hind legs, are visible (Fig. 1b). The belly girth area should also be bulging just anterior to the hind legs, but can become slightly sunken if the animal has not eaten recently. As long as the belly girth bulges after the animal is next offered food, indicating that the crocodilian is readily accepting food, no concern is warranted. BS 3 is the ideal body score value.

BS 4 (very good) is an exaggeration of BS 3 with larger bulges in the tail, jowl and belly girth regions. Generally, no action is required but slight adjustments can be implemented to ensure weight gain does not continue.

If energy in exceeds energy out, weight gain will occur and, if not controlled, will eventually result in the animal being classed as BS 5 (obese; Fig. 1c). This is commonly a symptom of over-feeding and lack of exercise in captive environments, particularly larger crocodilians in zoos, tourist facilities and breeding facilities. An individual management plan should be implemented for animals in this condition as the extra weight placed on the limbs when hauling out of the water, and on the belly when basking, places additional strain on internal organs (eg respiratory and circulatory systems), leading to other

health and reproductive issues. Often, educating crocodilian keepers and handlers is required on how to increase exercise by encouraging natural behaviours (eg swimming, jumping, etc.) before rewarding with smaller food portions and only when the desired behaviours are achieved. Offering food with little nutritional value (eg apples soaked in myoglobin or 3-cm lengths of empty sausage casings or bones with no meat) are also options when feeding is used as an environmental enrichment aid (eg tourist displays) to maintain rewards without adverse weight gain.

Converse to gaining weight, if an animal begins to lose weight from BS 3 status, active management should begin immediately because once an animal is firmly categorised as BS 2 (poor), it is indicative that the issue has been occurring for some time. Reviewing management and husbandry procedures such as feeding regime (food quality and quantity), temperature profiles, water quality, hygiene and disease management may provide some insight into the cause of decline and rectification required to remedy the decline. Veterinary advice may be required, but minimising stressors by reducing handling and noise, and providing dark areas are most beneficial. Keep the animal in the same routine and, if change is necessary, reducing the frequency and intensity of management tasks, including feeding, is preferable.

If the animal continues to decline and reaches BS 1 (Fig. 1a), it is unlikely that recovery will occur. Veterinary intervention should be sought and discussions on how to humanely end any suffering are appropriate. Crocodilians can persist for a long time with declining BS until eventually succumbing to starvation, disease and other complications, whereby euthanasia may be the more humane alternative.

Implementing CrocBSI in your facility

The advantage of CrocBSI is that anyone can be trained to categorise any crocodilian into these BS categories. Keepers and handlers should be automatically categorising animals at every interaction (feeding, cleaning, observing, moving, etc.) and any changes or concerns should be reported using the facility's management system to ensure early prevention and intervention.

When determining the category of a crocodilian, don't be tempted to use partial figures such as 2.5 or 3.7. This overcomplicates the process and introduces subjectivity that cannot be qualified. Instead, you can use terms such as moving towards BS 2 (from BS 3) which indicates that the animal in BS 3 is in a declining body score, or higher BS 3 indicating the animal is getting fatter, for example. These should trigger the required actions before the animal actually enters the new BS category where more involved intervention may be required.

It is useful to get in a veterinarian or crocodilian health assessor periodically (weekly, monthly or quarterly) to confirm the regular keepers BS assessment. When you observe an animal daily, subtle changes can be missed so new eyes may detect these subtleties.

For more information, contact the author at “sally@crocresearch.com.au”. Download CrocBSI [here](#).

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North America

USA

SUMMER CROCFEST 2024. Summer CrocFest took place on 29 June 2024 at ZooTampa in Tampa, Florida, USA. It was attended by approximately 300 guests and raised a total of \$US62,000. Proceeds have been transferred to Dr. Natalia Rossi at Wildlife Conservation Society (WCS), who will oversee specific in-country conservation efforts for Cuban (*Crocodylus rhombifer*) and American (*C. acutus*) crocodiles, including: supporting reintroduction programs; supporting spatial and reproductive ecology research and monitoring; and, strengthening protection programs. This project aims to build upon the vital life's work of Roberto (Toby) Ramos-Targarona, Manuel (Manolito) Alonso-Tabet and Roberto Rodríguez-Soberón, through a team of dedicated Cuban researchers who worked alongside them and learned from their experiences.

Despite the efforts of field teams in the regions of Zapata Swamp and Monte Cabaniguán Wildlife Refuge, the conservation status of these two species in Cuba has not improved and threats are intensifying. Illegal hunting of both species has increased and the population of Cuban crocodiles introduced in 1995 into Lanier Swamp on the Isla de la Juventud is now believed to be extinct.

CrocFest fundraisers are geared to increase awareness of and raise money for, international crocodilian conservation. Attendees were granted access to the full grounds of ZooTampa and treated to various feeding and training demonstrations. After an authentic Cuban meal, the evening concluded with a live auction conducted by CrocFest team member, Joe Wasilewski.

In addition to the above activities, two awards were presented at CrocFest. The “Rafael Crespo Award” by University of Florida’s “Croc Docs” was granted to Bryna Daykin (Fig. 1), Crocodylian Research Coordinator, University of Florida - Fort Lauderdale Research and Education Center. And CrocFest presented the inaugural “George Amato Award for Excellence in Science”. Dr. George Amato attended the award ceremony via video conferencing, received long-overdue appreciation for his decades-long contributions to the conservation genetics of crocodilians (Fig. 2).



Figure 1. Rafael’s Crespo’s parents, Mr. and Mrs. Rafael Crespo, Sr., with presenter Dr. Venetia Briggs-González and “Rafael Crespo Award” recipient Bryna Daykin.



Figure 2. Inaugural “George Amato Award for Excellence in Science” was presented remotely to Dr. George Amato.

A Summer CrocFest 2024 recap, courtesy of renowned filmmaker Aliesky del Rio, highlights the festivities of the event, and can be found [here](#).

Thanks to the generosity and commitment of the private sector, zoos and corporate sponsors all working together, as of June 2024, CrocFest fundraisers have generated over \$US962,000 for crocodilians in peril! ALL proceeds go directly to crocodilian projects, with event expenses covered by event organizers and sponsors.

Colette Adams, Curt Harbsmeier and Flavio Morrissiey, *CrocFest Organisers*.



Recent Publications

Brandt, L.A. (2024). Trends in American alligator pods in Arthur R. Marshall Loxahatchee National Wildlife Refuge. *Journal of Fish and Wildlife Management* (<https://doi.org/10.3996/JFWM-23-005>).

Abstract: Alligators are an important component of the Greater Everglades serving as ecosystem engineers, predator, prey, and are tightly tied to water depth patterns. Because of their importance to ecosystem function and link to hydrology, alligators are an ecological indicator for Everglades restoration. I used data from fall night-time spotlight surveys of alligators in the Arthur R. Marshall Loxahatchee National Wildlife Refuge to describe the trend in number of hatchling pods from 1998 to 2021 and relate that trend to hydrologic parameters hypothesized to influence alligator production. I used an information-theoretic approach to evaluate 14 models created from combinations of year of observation and three hydrologic variables: average and range in water depth from 16 April of the previous year to 15 April of the nesting year (breeding potential window) and average water depth from 16 April to 31 May of the nesting year (courtship and mating window). Number of pods ranged from 16 in 1998 to 0 in 2011. Each of the four top models included year and one or more of the hydrologic variables as predictors and explained 26-34% (D-squared) of the variation in number of pods. Year was the predictor for which the 95% confidence interval did not contain zero and indicated a declining trend (-3% to -8%; 95% confidence interval). All hydrologic variables were included in the top models indicating they contribute some information to explaining the trend; however, contrary to my hypotheses, there was not a clear relationship between any of the hydrologic variables and number of alligator pods. My hypotheses were based on information synthesized in the Alligator Production Suitability Index model being used in Everglades restoration planning and my results suggest that additional refinement of that model is warranted.

McKnight, L.M., Bibb, R. and Cooper, F. (2024). Seeing is believing - the application of three-dimensional modelling technologies to reconstruct the final hours in the life of an ancient Egyptian crocodile. *Digital Applications in Archaeology and Cultural Heritage* (<https://doi.org/10.1016/j.daach.2024.e00356>).

Abstract: The application of non-invasive radiography (X-ray and CT) to an ancient Egyptian crocodile mummy demonstrated a high level of corporeal preservation achieved through artificial embalming. Analysis revealed numerous anomalies within the abdomen of the crocodile which merited further investigation using digital three-dimensional modelling technologies. Improving

the clarity of the CT scan data enabled the authors to identify the anomalies which included a metal fish hook and a small fish. Segmentation of the CT scan data enabled the virtual extraction of the hook from within the confines of the mummy and its replication, firstly in plastic and then in its original material, bronze. Through the scientific analysis of the mummy, the authors reconstruct the biological biography and life history attributes of the animal, and consider the human-animal relationships and religious beliefs behind its post-mortem preservation. The study explores the application of the 3D technologies applied to archaeological materials and the novel implementation of experimental techniques to reproduce the anomaly. The investigation provided the ability to enhance the study, interpretation and display of the mummy; a matter of particular relevance in the case of mummified remains where anomalies are not directly visible. The authors consider the improved accessibility to cultural artefacts made possible through the application of enhanced visualization techniques in the heritage sector.

Lemaire, J., Bustamante, P. and Shirley, M.H. (2024). Preliminary assessment of blood mercury contamination in four African crocodile species. *Environment International* 190 (<https://doi.org/10.1016/j.envint.2024.108877>).

Abstract: Heavy metal contamination in the environment is an increasingly pervasive threat to the long-term persistence of wildlife. As high trophic level consumers, crocodylians are at substantial risk from bioaccumulation of mercury (Hg). Despite that they are generally well-studied and the focal species of many conservation efforts around the world, little is known about Hg contamination levels in most crocodylians. Here we preliminarily evaluate blood Hg contamination in four African species - Central African slender-snouted crocodile (*Mecistops leptorhynchus*), African dwarf crocodile (*Osteolaemus tetraspis*), West African crocodile (*Crocodylus suchus*), and Nile crocodile (*Crocodylus niloticus*) - from a diversity of sites and habitats across 5 different countries representing varying degrees of environmental pollution. All of our sampled crocodiles were Hg contaminated and, worryingly, these African crocodiles generally showed the highest levels of Hg contamination of any crocodylian species examined to date. Of most concern was that Hg concentrations were not only highest in *M. leptorhynchus*, the most threatened amongst our study species, but also in individuals sampled in what are believed to be some of the most remote and pristine natural areas left in Africa - Gabon's national parks. Our results underscore the need to better understand the impact of longstanding petroleum, mining, forestry, and agricultural industries on the entire aquatic food chain throughout much of Africa, including on the threatened species in these habitats and the human populations that depend on them for their subsistence and livelihoods.

Tan, W.C. (2024). Effects of Habitat Fragmentation on Herpetofauna in Southeast Asia: From Broad Scale Responses to Fine Scale Responses in an Ever-changing Anthropogenic Landscape. Dissertation, Rheinische Friedrich-Wilhelms-Universität Bonn, Bonn.

Abstract: Habitat loss and fragmentation are undoubtedly significant drivers of biodiversity loss worldwide, with Southeast Asia being a hotspot of biodiversity and facing numerous anthropogenic pressures. However, the impacts of habitat fragmentation on biodiversity are still not fully understood, and further research is required to determine the responses of different taxa to this threat. Reptiles and amphibians (herpetofauna), in particular, are among the most threatened groups globally, with Southeast Asia being home to a high diversity of species and facing imminent threats from habitat loss and fragmentation. By combining bibliographic analyses and macroecological methods, this thesis aims to contribute to the knowledge on the current global state of habitat fragmentation research in herpetofauna and the broad and fine scale responses of Southeast Asian reptiles to various forms of habitat fragmentation.

Chapter 1: This chapter provides a general introduction to the concepts of habitat fragmentation and its effects on biodiversity. It accentuates the importance of Southeast Asia for habitat fragmentation research due to its complex geological history, high species richness, and rapid habitat loss. It also describes the plight of the Southeast Asian herpetofauna, focussing on their vulnerability to habitat loss and fragmentation in freshwater environments. Lastly, the chapter gives a brief overview of the methodologies and approaches used throughout this thesis. Chapter 2: Recent decades have seen a surge of funding, published papers and citations in the field as threats to biodiversity continue to rise. However, how research directions and agenda are evolving in this field remains poorly understood. This chapter presents a global review of past and current state of research on habitat fragmentation for reptiles and amphibians. Here, I systematically reviewed published literatures on habitat fragmentation effects on reptiles and amphibians from 1990 to 2020, with the aims of identifying geographical and taxonomical trends on the various forms of habitat fragmentation, and the sampling methods and response variables commonly employed to identify them. The study reveals several patterns and biases in research efforts, such as the concentration of studies in wealthy and English-speaking countries, and the under-representation of certain regions (eg Africa and Southeast Asia) and taxa (eg caecilians, fossorial reptiles). It specifically calls for increased attention to these taxa in Southeast Asia, which have received less scientific scrutiny compared to other regions of the world. Moreover, there is a shift in research agendas towards studies utilising technological advancements including genetic and spatial data analyses. These findings suggest important associations between sampling methods and prevalent response variables but not with the forms of habitat fragmentation. This review suggests the need for more studies on genetic and spatial patterns, with emphasis on underrepresented reptile and amphibian taxa. This chapter sets the context for the subsequent chapters by highlighting the existing gaps in the field. Chapter 3: This chapter uses species distribution models to investigate the broad-scale responses of threatened semi-aquatic or freshwater reptiles to current and future climatic and anthropogenic conditions. More specifically, it examines the habitat suitability of endangered freshwater crocodiles and turtles and assesses the effectiveness of existing protected areas in conserving these species across Southeast and South Asia (in the Indomalayan realm). Species distribution models are highly successful in predicting potentially suitable habitats of a species based on their environmental niche and presence records. The results suggest that protected areas may be insufficient in the face of current anthropogenic pressures and future climate change. The chapter emphasises the importance of considering both climatic and non-climatic factors in species distribution models. The results of this chapter are essential for conservation planning and management, as they provide insights into important areas and reserves that should be prioritised. Chapter 4: This chapter zooms in from a broad-scale to fine-scale view of species response to habitat change, focusing on the effect of logging, which affects more than half of the remaining tropical forests in Southeast Asia. Logging has direct and indirect impacts on freshwater turtle habitats, such as altering stream hydrology and increasing sedimentation. In this chapter, I examine the fine-scale responses of two freshwater turtle species to Reduced Impact Logging, a sustainable forestry method, in Deramakot reserve in Sabah, Malaysian Borneo. I use occupancy models to estimate the probability of species detectability and habitat associations across a post-harvest recovery gradient (1-21 years since logging), using presence and absence data. Results for the non-threatened soft-shelled turtle, *Dogania subplana* are inconclusive. However, the study reveals a significant negative association between monthly rainfall and detection of the threatened hard-shelled turtle, *Notochelys platynota*. The occupancy probability of *N. platynota* is positively associated with greater distance from logging roads. Nevertheless, both species appear to be relatively common throughout the reserve. The chapter suggests that forests managed sustainably, ie using Reduced Impact Logging could serve as conservation areas for imperilled freshwater turtle species in the region. Lastly, chapter 5 summarises the results of this thesis and its implications and contributions to the field. It also considers the

limitations of the approaches and methodologies used. Overall, this thesis emphasises the urgent need for more research on the effects of habitat fragmentation on herpetofauna in Southeast Asia and the importance of incorporating both broad and fine-scale data. This work is a significant step towards providing easily reproducible studies to be used as baseline to ensure the long-term survival of these vulnerable species in Southeast Asia.

Aubert, C. (2024). Crocodile conservation: the value of community-based conservation and the contribution of drones as a new tool for inventorying and monitoring populations.

Abstract: Global biodiversity is under extreme pressure, marked by a significant increase in species extinctions over the last 300 years and a decline in most vertebrates over the last five decades, mainly due to human activities. Crocodilians have not been spared, with 50% of their species classified as threatened. It is therefore essential to improve the effectiveness of conservation programmes. This thesis contributes to broadening and deepening knowledge of conservation approaches and population inventory methods, with a particular focus on crocodilians. Through the community conservation approach, I emphasise the importance of involving indigenous peoples and local communities in conservation projects, taking into account the social, economic and environmental dimensions. Reconciling conservation and development objectives increases the chances of success and sustainability. My work has also led to the development of a standardised method for inventorying and monitoring crocodilians using drones. This efficient and non-invasive method is suitable for crocodilian species found in open environments. This technology, which is accessible to a range of users, including indigenous peoples and local communities, helps to empower them and protect ecosystems. This work opens up new prospects for conservation by combining community involvement in the conservation of crocodile species.

Resume: La biodiversité mondiale subit une pression extrême, marquée par une augmentation significative des extinctions d'espèces depuis plus de 300 ans et d'un déclin de la plupart des vertébrés ces cinq dernières décennies, principalement en raison des activités humaines. Les crocodiliens ne sont pas épargnés avec 50% de ses espèces catégorisées comme menacées. En conséquence, il est essentiel d'améliorer l'efficacité des programmes de conservation. Cette thèse contribue à élargir et approfondir les connaissances sur les approches de conservation et méthodes d'inventaire de population, avec un focus particulier sur les crocodiliens. A travers l'approche de la conservation communautaire, je souligne l'importance de l'association des peuples autochtone et communautés locales aux projets de conservation en considérant les dimensions sociales, économiques et environnementales. Concilier les objectifs de conservation et de développement permet d'augmenter les chances de succès et de durabilité. Par ailleurs, mes travaux ont permis de développer une méthode standardisée d'inventaire et de suivi des crocodiliens à l'aide de drones. Cette méthode, efficace et non invasive, est adaptée pour les espèces de crocodiliens des milieux ouverts. Cette technologie, accessible à divers utilisateurs, incluant les peuples autochtones et communautés locales, favorise leur autonomisation et la protection des écosystèmes. Ce travail offre des perspectives pour la conservation en associant l'engagement communautaire et les avancées technologiques, pour une approche plus efficace, inclusive et durable. Mot clés : conservation communautaire, peuples autochtones et communautés locales, crocodiliens, conflits humains-crocodiles, drone, inventaire et suivi de population.

Zhang, J. and Wu, X. (2024). The whole genome DNA methylation signatures of hindlimb muscles in Chinese alligators during hibernation and active periods. *Animals* 14: 1972.

Abstract: Many ectotherms hibernate to increase their chances of survival during harsh winter conditions. The role of DNA methylation

in regulating gene expression related to hibernation in ectotherms remains unclear. Here, we employed whole-genome bisulfite sequencing (WGBS) technology to construct a comprehensive genome-wide DNA methylation landscape of the hindlimb muscles in the Chinese alligator during hibernation and active periods. The results indicated that methylation modifications were most abundant at CG sites, identifying 9447 differentially methylated regions (DMRs) and 2329 differentially methylated genes (DMGs). KEGG pathway enrichment analysis of the DMGs revealed significant enrichment in major pathways such as the neurotrophin signaling pathway, the MAPK signaling pathway, the GnRH signaling pathway, the biosynthesis of amino acids, and the regulation of the actin cytoskeleton, which are closely related to lipid metabolism, energy metabolism, and amino acid metabolism. Among these, 412 differentially methylated genes were located in promoter regions, including genes related to energy metabolism such as ATP5F1C, ATP5MD, PDK3, ANGPTL1, and ANGPTL2, and genes related to ubiquitin-proteasome degradation such as FBXO28, FBXO43, KLHL40, and PSMD5. These findings suggest that methylation in promoter regions may play a significant role in regulating the adaptive hibernation mechanisms in the Chinese alligator. This study contributes to a further understanding of the epigenetic mechanisms behind the hibernation of the Chinese alligator.

Lima, M.O., Gorza, L.L., Borges, E.J.S., De Paula, V.T., Nunes, L.C., Nobrega, Y.C., Figueiredo, R.G. and Da Silva, M.A. (2024). Morphological comparison of the larynx and trachea of *Chelonia mydas* (Linnaeus, 1758), *Caiman yacare* (Daudin, 1802) and *Caiman latirostris* (Daudin, 1802). *Anais da Academia Brasileira de Ciências* 96(3): e20230753.

Abstract: The larynx is in the lower respiratory tract and has the function of protecting the airways, controlling, and modulating breathing, assisting the circulatory system, and vocalizing. This study aims to describe the anatomy and histology of the skeleton of the larynx and trachea of the species *Chelonia mydas*, *Caiman yacare* and *Caiman latirostris*. The study was conducted at the Federal University of Espírito Santo (UFES), using nine specimens of *Ch. mydas*, 20 of *Ca. yacare* and four of *Ca. latirostris*. Samples of the larynx and trachea were collected, fixed, and sent for dissection of the structures and subsequent macroscopic analysis. For histology, samples were processed by the routine paraffin embedding method and stained with hematoxylin-eosin and Verhoeff. For the three species, two arytenoid cartilages, a cricoid cartilage, a hyoid apparatus composed of a base and two horns were found. In *Ch. mydas*, two structures called thyroid wings were observed, not found in crocodilians. The trachea of crocodilians presented incomplete tracheal rings and musculature, while the trachea of *Ch. mydas* presented complete tracheal rings. Histologically, the entire cartilaginous skeleton of the larynx of the three species, as well as the tracheal rings, are constituted by hyaline cartilage.

Brackzkowski, A., Ochse, L., Atukwatse, B., Cornille, O., O'Bryan, C., Lindsey, P., Kotze, R., Gibson, L. and Biggs, D. (2024). Long-distance swimming by African lions in Uganda. *Ecology and Evolution* 14(7): e11597.

Abstract: Earth's most imperiled and iconic wildlife are facing tough decisions under increasing human pressure and limited resources. Swimming across rivers and water bodies filled with high densities of predators may be one such example. In African lions *Panthera leo*, previous water crossings (recorded in the peer-reviewed and gray literature, on film, and found using Google Search, and YouTube) have recorded distances ranging from <10 to 100 m, with some resulting in mortality by Nile Crocodiles *Crocodylus niloticus*. However, we observed a coalition of male lions swimming >1 km across Uganda's Kazinga channel located in the Queen Elizabeth National Park six times, and recorded this behavior on film on February 1st 2024. We speculate that three factors could be driving these lions to take long-distance swims with a high density of

crocodiles and hippos *Hippopotamus amphibius*, namely (1) the lack of lionesses in this ecosystem, (2) intraspecific fights over territory with other male coalitions, and (3) the only other land connection giving lions access to the peninsula is a small road bridge with a strong human presence.

Wang, C., Li, C., Liu, P., Zhang, S., Zhou, Y., Zhang, X., Wang, Y., Liu, R., Wu, X. and Nie, H. (2024). The impact of host development and density stress on the diversity of microbial communities in the gut and its surrounding environment of the Chinese alligator. *Ecology and Evolution* (<https://doi.org/10.1002/ece3.11667>).

Abstract: The Chinese alligator (*Alligator sinensis*) is currently an endangered species due to a combination of factors, including climate change, anthropogenic activities, and habitat fragmentation. Captivity plays a crucial role in mitigating the decline of the Chinese alligator population. Currently, there is a lack of clarity regarding the influence of host development and captive conditions on the gut microbiota of Chinese alligators. The aim of the study was to investigate the gut bacterial communities of Chinese alligators and their surrounding environmental bacterial communities using 16S rRNA sequencing. The primary gut flora of Chinese alligators consists of Proteobacteria, Bacteroidetes, and Firmicutes. Proteobacteria is the most abundant and efficient settler in the gut, water, and sediment. PCoA and Adonis test revealed significant differences in bacterial communities across these habitats. Venn analysis revealed overlap in OTUs among the gut, water, and sediment, varying with growth stage and density stress. Different growth stages of Chinese alligator guts harbor distinct pathogenic bacteria, requiring attention. Density stress leads to an increase in pathogenic bacteria, a decrease in gut absorption efficiency. PICRUSt2 predicts more abundant metabolic pathways related to gut function during high-density stress, possibly linked to Roseburia. SourceTracker Analysis indicated that water bacteria have a greater impact on Chinese alligator gut bacteria than sediment, and density stress significantly affects the contribution of environmental microorganisms to the gut microbes of Chinese alligator. BugBase analysis identified water body microbes as the main source of “potentially pathogenic” phenotypes in the gut microbiota. RDA analysis found dissolved oxygen (DO) in water to be the most significant factor influencing water microorganisms, positively correlated with certain pathogenic strains. These findings enhance our understanding of the significance of microbial communities in the gut and surrounding aquatic environment of the Chinese alligator. Furthermore, they provide theoretical support for environmental regulation, disease control, and healthy breeding.

Kuzmin, I.T., Sichinava, E.A., Mazur, E.V. and Gomboleviskiy, V.A. (2024). Virtual reconstruction of the neurocranial anatomy of *Kansajsuchus extensus* (Neosuchia: Paralligatoridae) from the Upper Cretaceous of Tadzhikistan with a review of braincase osteology in Neosuchia. *Cretaceous Research* (<https://doi.org/10.1016/j.cretres.2024.105959>).

Abstract: The braincase features appear phylogenetically informative and key in assessing the still contentious relationships within Crocodylomorpha. Yet, the neurocrania of many non-crocodylian taxa are imperfectly studied. In the present paper, we describe the braincase osteology and neuroanatomy of a paralligatorid crocodylomorph *Kansajsuchus extensus* from the Upper Cretaceous Kansai locality in Tadzhikistan based on CT-scanning, segmentation, and 3D modeling. The detailed comparison of *K. extensus* with other taxa expands our understanding of the neurocranial anatomy and evolution in Neosuchia. The braincase anatomy appears to be relatively consistent across most non-crocodylian neosuchians, but important changes in its structure are traced through the neosuchian-eusuchian transition and especially at the base of Crocodylia. We question the close affinities of Dyrosauridae and Pholidosauridae based on significant differences in their braincases.

Schilling-Tóth, B.M., Belcher, S.M., Knotz, J., Ondrašovičová, S., Bartha, T., Tóth, I., Zsarnovszky, A. and Kiss, D.S. (2024). Temperature-dependent sex determination in crocodilians and climate challenges. *Animals* 14(13) (<https://doi.org/10.3390/ani14132015>).

Abstract: The sex of crocodilians is determined by the temperature to which the eggs, and hence the developing embryo are exposed during critical periods of development. Temperature-dependent sex determination is a process that occurs in all crocodilians and numerous other reptile taxa. The study of artificial incubation temperatures in different species of crocodiles and alligators has determined the specific temperature ranges that result in altered sex ratios. It has also revealed the precise temperature thresholds at which an equal number of males and females are generated, as well as the specific developmental period during which the sex of the hatchlings may be shifted. This review will examine the molecular basis of the sex-determination mechanism in crocodilians elucidated during recent decades. It will focus on the many patterns and theories associated with this process. Additionally, we will examine the consequences that arise after hatching due to changes in incubation temperatures, as well as the potential benefits and dangers of a changing climate for crocodilians who display sex determination based on temperature.

Young, M.T., Dufeu, D., Bowman, C., Cowgill, T., Schwab, J.A., Witmer, L.M., Herrera, Y., Katsamenis, O.L., Steel, L., Rigby, M. and Brusatte, S.L. (2024). Thalattosuchian crocodylomorphs from the Sinemurian (Early Jurassic) of the UK. *Zoological Journal of the Linnean Society* 201(3) (<https://doi.org/10.1093/zoolinnean/zlae079>).

Abstract: Thalattosuchian crocodylomorphs were a ubiquitous component of shallow marine ecosystems during the Jurassic and Early Cretaceous. Alas, their origins remain a mystery. Here we describe three specimens from the Sinemurian (and possibly Early Pliensbachian) of the UK: a partial cranial rostrum, a series of cervical vertebrae, and two dorsal vertebrae adhered with matrix. These specimens are amongst the oldest known thalattosuchian fossils, with the partial cranial rostrum being the oldest known non-neothalattosuchian thalattosuchian. This partial cranial rostrum has a unique combination of rostral characters never seen before in any crocodylomorph, and helps to elucidate early thalattosuchian internal rostrum evolution, suggesting that the reduction in thalattosuchian paranasal sinuses was not related to either the reorganization of rostral neurovasculature seen in later diverging taxa or the increased cancellous bone microstructure. Based on our CT sample, a shift in cranial bone microstructure occurred in the Eoneustes + Metriorhynchidae subclade, one that coincided with the enlargement of the salt glands and decoupling of the external antorbital fenestra from the paranasal sinuses. Without extensive histological sampling we cannot determine whether the shift to an obligate aquatic lifestyle occurred prior to the evolution of Metriorhynchidae.

Serrano, O.S., Garcês, A., Pires, I., Calderón Mateus, J.A., Olivera, J.M. and Dávila, J.J. (2024). Congenital anomalies in American crocodile (*Crocodylus acutus*, Cuvier, 1807) embryos from a farm breeder in Colombia. *Veterinary Sciences* 11: 317.

Abstract: The American crocodile (*Crocodylus acutus*, Cuvier, 1807) (Class Reptilia, Family Crocodylidae) is a crocodile species inhabiting the Neotropics. Congenital defects have been described in almost every vertebrate group. In crocodiles, teratology alterations have been described in captive animals (pets, zoos, farms) such as *Crocodylus niloticus* or *Gavialis gangeticus*. The present study aimed to characterize congenital malformations of *C. acutus* from a farm in Lomas de Matunilla, Ballestas, Bolívar, Colombia. A total of 550 unhatched eggs were examined after embryo death. A total of 61 embryos presented malformations, with 42 different types of

anomalies observed. Limb and tail malformations (29%) were the most common malformations observed. Several malformations, such as cephalothoracopagus, thoracopagus, sternopagus, xiphopagus twins, campylorachis scoliosa, and acrania, were documented in crocodiles for the first time. Research in teratology enhances our understanding of crocodile biology. It plays a role in their conservation and management, thus helping to ensure the long-term viability of these species in their natural habitats.

Chala, G., Karthikeyan, R. and Tesfaye, T. (2024). Optimizing soft leather production from back cut skins: Sustainable practices at Ethiopian Nile crocodile farms. JALCA 119: 331-338.

Abstract: This research addresses the significant challenges in converting back cut skins of Nile crocodiles (*Crocodylus niloticus*) into soft leather. The process is complicated by the skins' inherent hardness and distinct texture. Sourced from the Arba Minch Crocodile Farm, these skins are aesthetically pleasing due to their unique scale patterns. However, they are often overlooked by leather manufacturers because of their rigidity and the complexities involved in processing. Our study proposes a critical modification in the pickling and chrome tanning process, specifically designed to improve fiber opening and separation. This method effectively transforms the durable back cut skins into flexible, soft leather, enhancing their applicability in various leather goods. Furthermore, the research encompasses an extensive evaluation of the raw materials, focusing on their fat and nitrogen composition. Advanced techniques, such as scanning electron microscopy analysis, along with visual examinations and physical tests, affirm the modified tanning process's efficacy in producing soft leather from crocodile back cut skins. These findings underscore the potential of this refined approach not only to overcome processing challenges but also to expand the use of back cut skins in the leather industry. This research not only offers new opportunities for product diversification but also promotes sustainable practices at Ethiopian Nile Crocodile Farms, contributing to innovative and environmentally responsible leather production methods.

Sachs, S., Young, M.T., Hornung, J.J., Cowgill, T., Schwab, J.A. and Brusatte, S.L. (2024). A new genus of metriorhynchid crocodylomorph from the Lower Cretaceous of Germany. Journal of Systematic Palaeontology 22(1) (<https://doi.org/10.1080/14772019.2024.2359946>).

Abstract: Here we describe a new genus and species of metriorhynchid crocodylomorph, *Enalioetes schroederi* gen. et sp. nov., from the lower Valanginian Stadthagen Formation (Lower Cretaceous) of north-western Germany. *Enalioetes schroederi* is the most complete and well-preserved Cretaceous metriorhynchid skull known to date, preserving most of the cranium and mandible, the atlas-axis complex and the first postaxial cervical vertebra. The specimen was previously attributed to the coeval enigmatic metriorhynchid *Enaliosuchus* (a *nomen dubium*) and, more recently, to *Cricosaurus*. Although the specific epithet *schröderi* has been used frequently in the literature, it has never been formally established. Herein, we demonstrate that the new taxon is distinct from all known metriorhynchids by a unique combination of characters including several autapomorphies such as: the lack of bulbous dorsolateral expansion in the posterior nasal cavity; mediolateral distance between the orbital canals being approximately 1.5 times the diameter of the orbital canals; lacrimal with dorsoventrally deep anterior process ventral to the preorbital fossa being equal to or greater than the depth of the jugal anterior process and the anterodorsal process of the lacrimal; and ascending processes at atlas intercentrum extending far dorsally to level of neural canal. *Enalioetes schroederi* contributes to the sparse global record of Cretaceous metriorhynchids and represents one of the stratigraphically youngest occurrences of the group. It can thus help to enhance our understanding of the metriorhynchid diversity during the Cretaceous Period.

Esmaili, D., Salas, K.R., Luker, H.A., Mitra, S., Galvan, C.J., Holguin, F.O., Whyms, S., Hansen, I.A. and Costa, A.G. (2024). Rancid rumors or Native wisdom: Evaluating the efficacy of animal fats as insect repellents attributed to historic-period Native Americans. PLoS One 19(7): e0301677.

Abstract: Little is known about Native American adaptations to blood-sucking arthropods prior to and following European contact. Multiple accounts starting in the 16th century suggest that rancid animal grease was employed by Gulf Coast indigenes as a mosquito repellent. Although many Native American ethnobotanical remedies for biting insects have been recorded, the use of animal products for this purpose is not well documented. Moreover, few traditional Native American mosquito repellents have been examined using controlled laboratory methods for repellency testing. In this study, we tested the repellent efficacy of fats derived from alligator, bear, cod, and shark that were aged to various stages of rancidity. Using yellow fever mosquitoes, (*Aedes aegypti*), we performed an arm-in-cage assay to measure the complete protection times resulted from these fats, when applied to human skin. We used a Y-tube olfactometer assay to evaluate long-distance repellency and tested tick-repellency in a crawling assay. Our results suggest that rancid animal fats from cod, bear, and alligator are potent albeit short-lived mosquito repellents. We found that both rancid and fresh fats do not repel ticks. Our findings show the validity of traditional ethnozoological knowledge of Native American people and support aspects of the ethnohistorical record.

Guimaraes, M.M., Bernardes-de-Souza, D., da Costa, M.C.A., Paes, D.C.A.d.S., de Souza, M.P. and Riva, F.R. (2024). Inclusive value chain analysis of alligator meat in the Lago do Cuniã Extractive Reserve in Brazilian Amazon. Academia Revista Latinoamericana de Administración (<https://doi.org/10.1108/ARLA-12-2022-0241>).

Abstract: The aim of this paper was to analyze the role of the Cooperative of Farmers and Fishermen of the Lago do Cuniã Extractive Reserve (COOPCUNIÃ) in the inclusion of residents in the caiman meat value chain in Porto Velho, Brazil. A total of six interviews were conducted with key actors to investigate the research problem in the Lago do Cuniã EXRES, namely the president and project advisor of the cooperative, two extractivist members of the cooperative and two non-member residents. The key actors were selected based on the following criteria: being over 18 years old, residing within the reserve and having participated in some stage of the caiman meat value chain. The results demonstrate that the cooperative contributes to the inclusion of extractivist residents in the value chain, income generation and poverty reduction, enabling the production and marketing of caiman meat. Additionally, it overcomes challenges and improves the quality of life of the local population. This study emphasizes the social and economic benefits for isolated regions with low productive development. For public policymakers, the results demonstrate that inclusion has enabled access to technology and markets. For the cooperative, it showcases actions oriented towards development, social inclusion and quality of life.

Resumen: O objetivo foi analisar o papel da Cooperativa dos Agricultores e Pescadores da Reserva Extrativista Lago do Cuniã (COOPCUNIÃ) na inclusão dos moradores na cadeia de valor da carne de jacaré em Porto Velho, Brasil. Foram realizadas 6 (seis) entrevistas com atores-chave para investigar o problema de pesquisa na RESEX Lago do Cuniã, a saber: o presidente e o assessor de projetos da cooperativa, dois extrativistas cooperados e dois moradores não cooperados. Os atores-chave foram selecionados com base nos seguintes critérios: ser maior de 18 anos, residir na reserva e ter participado de alguma etapa da cadeia de valor da carne de jacaré. Os resultados demonstram que a cooperativa contribui para a inclusão dos extrativistas na cadeia de valor, com a geração de renda e redução da pobreza, viabilizando a produção e comercialização da carne de jacaré. Além disso, supera desafios e melhora a qualidade de vida da população local. Este estudo enfatiza

os benefícios sociais e econômicos para regiões isoladas e com baixo desenvolvimento produtivo. Para os formuladores de políticas públicas, os resultados demonstram que a inclusão possibilitou o acesso à tecnologia e aos mercados. Para a cooperativa, mostra ações voltadas para o desenvolvimento, inclusão social e qualidade de vida. A originalidade do artigo está na análise do papel de uma cadeia de valor dentro de uma área de proteção ambiental na Amazônia, equilibrando fatores econômicos, sociais e ambientais.

Rawson, J., Deakin, W.J., Stubbs, T.L., Smith, T.J., Rayfield, E.J. and Donoghue, P.C.J. (2024). Widespread convergence towards functional optimisation in the lower jaws of crocodile-line archosaurs. *Proceedings of the Royal Society B: Biological Science* 291: 20240720.

Abstract: Extant crocodilian jaws are subject to functional demands induced by feeding and hydrodynamics. However, the morphological and ecological diversity of extinct crocodile-line archosaurs is far greater than that of living crocodilians, featuring repeated convergence towards disparate ecologies including armoured herbivores, terrestrial macropredators, and fully marine forms. Crocodile-line archosaurs therefore present a fascinating case study for morphological and functional divergence and convergence within a clade across a wide range of ecological scenarios. Here we build performance landscapes of two-dimensional theoretical jaw shapes to investigate the influence of strength, speed and hydrodynamics in the morphological evolution of crocodile-line archosaur jaws, and test whether ecologically convergent lineages evolved similarly optimal jaw function. Most of the 243 sampled jaw morphologies occupy optimised regions of theoretical morphospace for either rotational efficiency, resistance to Von Mises stress, hydrodynamic efficiency or a trade-off between multiple functions, though some seemingly viable shapes remain unrealised. Jaw speed is optimised only in a narrow region of morphospace whereas many shapes possess optimal jaw strength, which may act as a minimum boundary rather than a strong driver for most taxa. This study highlights the usefulness of theoretical morphology in assessing functional optimality, and for investigating form-function relationships in diverse clades.

Grand Pré, C.A. (2024). The Hepatic Piston Mechanism in Crocodylomorpha: Functional Anatomical Reconstructions in Terrestrial and Aquatic Taxa. PhD thesis, Louisiana State University, USA.

Stout, J.B. (2024). Osmoregulation in Alligatoroidea: shifting the paradigm untethers biogeographic questions. *Historical Biology* (<https://doi.org/10.1080/08912963.2024.2379029>).

Abstract: A pervasive maxim in herpetology is that alligators (Alligatoridae) are poor salinity regulators relative to their taxonomic kin, crocodiles (Crocodylidae), evidenced by the purported lack of osmoregulatory abilities of modern Alligator and caimans, which has led to the assumption that freshwater obligation is synapomorphic across the clade, to include extinct members of Alligatoridae, or even Alligatoroidea. Presented here is a brief review of osmoregulation and the fossil record of alligatoroids and a suggestion that salt-tolerance may have been more widespread in the group than is widely assumed, based upon the observations that 1) modern alligatorids are increasingly reported from brackish and marine environs and possess osmoregulatory abilities attained through different regulatory pathways than their crocodile counterparts, and 2) fossil members of the group are routinely (or exclusively) found in or near marine depositional settings, suggesting plausibility that earlier members of the clade were more ocean-going than their extant descendants. Starting with fewer assumptions about the osmoregulatory abilities of extinct taxa may help solve continuing problems in eusuchian biogeography, namely, the dispersals of alligatoroids into Europe and Asia, and multiple dispersal events to

and from pre-Interchange South America. Secondary loss of salinity tolerance in *Alligator* may be adaptive in continental habitats.

Doarks, T. and Arbuckle, K. (2024). Predictors of animal sponsorship to support zoo-based conservation activities. *Conservation Science and Practice* 2024: e13173.

Abstract: Public donations are an important form of fundraising for zoos and are used to support conservation activities. Understanding what influences zoo animal sponsorship by the public is crucial if zoos are to optimize strategies for increasing income from sponsors. Using sponsorship data obtained from seven diverse zoos within the UK, we used a phylogenetically informed approach to investigate predictors of the number of sponsors a species receives. We found no support for an effect of body mass, conservation status, solitary versus group housing, phylogenetic distance from humans, daily activity patterns, or the diet of the species on the number of sponsors a species attracts. However, we found strong phylogenetic signal, suggesting that particular groups of animals attract disproportionate sponsorship attention (but the specific species within these groups is of limited importance). Moreover, we found support for species with common names that are found toward the start of the alphabet having more sponsors. This is likely driven by the common practice of listing species that can be sponsored in alphabetical order when presenting them to potential sponsors (with people being more likely to choose species near the start of a list). Interestingly, the lack of effect of body mass, phylogenetic distance, and conservation status contrast with previous work on non-zoo conservation preferences, suggesting possible differences between motivations of zoo and non-zoo conservation donors, or between animal sponsorship and other forms of conservation involvement. We suggest two strategies for maximizing sponsorship for zoo animals. If zoos manage sponsorship income as a collective pool then allowing sponsorship of a range of species within particularly well-sponsored animal groups should improve uptake. Alternatively, if zoos allocate sponsorship income to the specific species sponsored, then funding may be effectively diverted to priority species simply by altering the order of lists of animals which can be sponsored.

Pritz, M.B. (2024). Nuclei and tracts in the telencephalon of crocodiles: Identification and characterization using an organizational scheme applicable to other reptiles. *Journal of Comparative Neurology* 532(7): e25659.

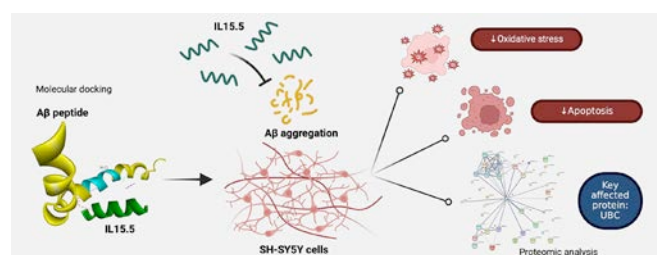
Abstract: The telencephalon of reptiles has been suggested to be the key to understanding the evolution of the forebrain. Nevertheless, a meaningful framework to organize the telencephalon in any reptile has, with rare exception, yet to be presented. To address this gap in knowledge, the telencephalon was investigated in two species of crocodiles. A variety of morphological stains were used to examine tissue in transverse, horizontal, and sagittal planes of sections. Besides providing a description of individual nuclei, brain parts were organized based on two features. One was related to two fixed, internal structures: the lateral ventricle and the dorsal medullary lamina. The other was the alignment of neurons into either layers, cortex, or not, nucleus. Viewed from this perspective, all structures, with limited exceptions, could be accurately placed within the telencephalon regardless of the plane of section. Furthermore, this framework can be applied to other reptiles. A further extension of this scheme suggests that all structures in the telencephalon could be grouped into one of two categories: pallial or basal.

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). Combined screening and retroactive data mining for emerging perfluoroethers in wildlife and pets in the Cape Fear region of North Carolina. *Chemosphere* (<https://doi.org/10.1016/j.chemosphere.2024.142898>).

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 archived seabird tissue data from previously reported exposure studies in order to extend the panel of detected novel PFAS. In this study, the compounds CF₃-(OCF₂)_x-COOH, x= 6, 7, 8 (Abbreviated PFO6TeDA, PFO7HxDA, PFO8OcDA, respectively), and 6H-Perfluoro-3-oxa,4-methylhexanesulfonic acid (Nafion byproduct 6) were detected for the first time in environmental tissues even though these analytes were not previously detected in the CFR. Analytical standards were available for PFO6TeDA and Nafion Byproduct 6, and therefore, were quantitated in investigated tissues. PFO7HxDA and PFO8OcDA had no available standards and were semi-quantitated using NTA techniques. Of note, PFO6TeDA, PFO7HxDA, and PFO8OcDA were observed in alligator, bass, and seabird but not horse and dog. PFO6TeDA was detected at the highest frequency in all investigated tissues with PFO7HxDA and PFO8OcDA detected at lower frequencies. No Nafion Byproduct 6 values are reported in serum due to poor analytical reproducibility of the measurements. Seabird tissue to blood ratios suggests PFO6TeDA 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.

Yubolphan, R., Joompang, A., Roytrakul, S., Boonyarat, C., Choowongkamon, K., Daduang, S., Klaynongsruang, S. and Jangpromma, N. (2024). Molecular docking and proteomics approaches for the identification of neuroprotective effects of IL15.5 peptide against oxidative stress-induced apoptosis in SH-SY5Y neurons. *Journal of Functional Foods* 119: 106354 (<https://doi.org/10.1016/j.jff.2024.106354>).

Abstract: Amyloid- β (A β) aggregation is central to Alzheimer's disease (AD), causing oxidative and synaptic damage. We developed IL15.5, a peptide-base inhibitor derived from IL15, a natural peptide from Siamese crocodile hemoglobin. Computational and molecular assays confirm IL15.5 effectively inhibits A β 42 aggregation, evident in thioflavin T assay results. IL15.5 also demonstrates acetylcholinesterase inhibition and antioxidant activity. It protects SH-SY5Y cells from oxidative stress and apoptosis, influencing caspase 3/MAPK pathways. Proteomic analysis reveals the role of IL15.5 in oxidative stress mitigation, affecting proteins linked to DNA repair, inflammation, and cell migration, with a significant association with Ubiquitin C. These findings suggest the potential of IL15.5 as an anti-amyloidogenic agent for AD treatment, offering neuronal protection and highlighting its therapeutic promise.



Viljoen, D., Webb, E., Myburgh, J., Truter, C., Van Wyk, J. and Myburgh, A. (2024). Thermal profiles associated with nest site selection of Nile crocodiles (*Crocodylus niloticus*) on a commercial crocodile farm. Available at SSRN: <https://ssrn.com/abstract=4902640> or <http://dx.doi.org/10.2139/ssrn.4902640>.

Abstract: Understanding crocodile nest site selection is important in the context of climate change and related habitat alterations. This study assessed a current nesting environment on a crocodile farm in South Africa, examining associations between various nest

site selection parameters, with a particular emphasis on the role of temperature. It was hypothesized that thermal profiles within nests and factors affecting nest temperatures (orientation, shading, grassy cover) would directly impact nest site selections, nests closer to waterbodies would be preferred, dominant females would dictate nesting area use, and human presence would not impact nesting behaviours as farmed crocodiles are accustomed to this. Nile crocodiles in this study produced nests of similar depth to wild Nile crocodiles, and subsurface temperatures varied with nesting layouts (section, orientation, shading), climate factors, and grass growth. Although a complex interaction of factors affected nest site selections, mean subsurface nest temperatures tended to fit into the narrow range of 25-26°C, highlighting a measure of stability within the nesting environment. Daily temperatures and temperature ranges did however vary significantly between crocodile-selected nesting depths. Grassy growth over nesting sites reduced the surface and subsurface temperatures of those nests. Although this did not affect nesting site occupancy, crocodiles selected against depositing eggs in these sites. Nests closer to waterbodies and tourist walkway were occupied more frequently; however, successful nesting occurred further from the walkway. The size (snout-hindlimb length) of crocodiles within nesting sites did not correlate to preferred nesting sections within the pen. Further research is needed to determine if thermally optimal nesting conditions might be complicated by climate change related nesting environment alterations on commercial farms.

Lindblad, K.T. (2024). Diversity and Structure of Late Cretaceous-Paleogene Crocodyliform Communities in Southern Saskatchewan, Canada. MSc thesis, University of Saskatchewan, Saskatoon, Canada.

Abstract: Crocodyliform fossils of extinct relatives and members of modern families are common finds in southern Saskatchewan, Canada, spanning a largely continuous interval of the Upper Cretaceous and Paleogene. Although this location represents the northernmost known extent of many well-known taxa, only a few individuals are documented in the literature, demonstrating the importance of Saskatchewan to the study of early crown-group crocodylians from the area. This study approaches these fossil crocodylians from multiple angles; describing previously unpublished specimens, examining the stratigraphy and taphonomy of the most notable quarries, and identifying patterns of the microvertebrate sites of the latest Maastrichtian Frenchman Formation in a case study to learn about the composition, ecology, and taphonomic overprints of this crocodyliform community. Almost all crocodylians known from Alberta and the northern United States over the span of the Campanian to late Eocene are confirmed to be (or are likely) present in Saskatchewan, including multiple species of *Borealosuchus*, and various alligatoroid genera. *Borealosuchus* is the most common and longest-lived crocodyliform represented, persisting in Saskatchewan from about 66.3 to 59 million years ago. This genus is preserved in a variety of freshwater habitats over this time interval, demonstrating resilience and flexibility in the face of ecosystem changes that occurred across the Cretaceous-Paleogene (K-Pg) boundary and well into the Paleocene. Most Frenchman Formation microsites show an elevated number of osteoderms and teeth compared to fragments of skeletal material. This likely represents a preservation bias due to each individual animal having hundreds of osteoderms and teeth. Additionally, the smaller teeth are the most common, likely representing an abundance of small and/or young individuals shedding teeth at a greater rate. This resembles the population structure in other extinct and modern crocodyliform communities, suggesting similar life histories.

Mallon, J.C. and Hone, D.W.E. (2024). Estimation of maximum body size in fossil species: A case study using *Tyrannosaurus rex*. *Ecology and Evolution* 14(7): e11658.

Abstract: Among extant species, the ability to sample the extremes

of body size - one of the most useful predictors of an individual's ecology - is highly unlikely. This improbability is further exaggerated when sampling the already incomplete fossil record. We quantify the likelihood of sampling the uppermost limits of body size in the fossil record using *Tyrannosaurus rex* Osborn, 1905 as a model, selected for its comparatively well-understood life history parameters. We computationally generate a population of 140 million *T. rex* (based on prior estimates), modelling variation about the growth curve both with and without sexual dimorphism (the former modelled after *Alligator mississippiensis*), and building in sampling limitations related to species survivorship and taphonomic bias, derived from fossil data. The 99th percentile of body mass in *T. rex* has likely already been sampled, but it will probably be millennia before much larger giants (99.99th percentile) are sampled at present collecting rates. Biomechanical and ecological limitations notwithstanding, we estimate that the absolute largest *T. rex* may have been 70% more massive than the currently largest known specimen (~15,000 vs. ~8800 kg). Body size comparisons of fossil species should be based on ontogenetically controlled statistical parameters, rather than simply comparing the largest known individuals whose recovery is highly subject to sampling intensity.

Joger, U. (2024). Introduction to the Reptilia. Chapter 1 in *Handbook of Zoology. Volume 1, General Biology, Archosauria, Chelonian*, ed. by U. Joger. De Gruyter: Boston.

Delfino, M. and Villa, A. (2024). An overview of the skeleton of reptiles. Chapter 3 in *Handbook of Zoology. Volume 1, General Biology, Archosauria, Chelonian*, ed. by U. Joger. De Gruyter: Boston.

Gregorovicova, M. (2024). Cardiovascular system in reptiles. Chapter 4 in *Handbook of Zoology. Volume 1, General Biology, Archosauria, Chelonian*, ed. by U. Joger. De Gruyter: Boston.

Buffa, V. and Laurin, M. (2024). Paleozoic origin of major reptile groups. Chapter 5 in *Handbook of Zoology. Volume 1, General Biology, Archosauria, Chelonian*, ed. by U. Joger. De Gruyter: Boston.

Sues, H-D. (2024). Archosaur relatives and Pseudosuchians. Chapter 6 in *Handbook of Zoology. Volume 1, General Biology, Archosauria, Chelonian*, ed. by U. Joger. De Gruyter: Boston.

Sues, H-D. (2024). Crocodyliformes - Crocodylia and their relatives. Chapter 7 in *Handbook of Zoology. Volume 1, General Biology, Archosauria, Chelonian*, ed. by U. Joger. De Gruyter: Boston.

Henriquez, J.I. and Richman, J.M. (2024). Resilience of the replacing dentition in adult reptiles. *Developmental Biology* (<https://doi.org/10.1016/j.ydbio.2024.07.013>).

Abstract: The dentition is critical to animal survival and teeth are present in modern vertebrates including teleost fish, sharks, amphibians, mammals and reptiles. The developmental processes that give rise to teeth are not just preserved through evolution but also share high level of similarity with the embryogenesis of other ectodermal organs. In this review we go beyond the embryonic phase of tooth development to life-long tooth replacement. We will address the origins of successional teeth, the location of putative tissue-resident stem cells, how *de novo* tooth formation continues throughout life and how teeth are shed in a spatially and temporally controlled manner. We review the evidence that the dental epithelium, which is the earliest recognizable dental structure in the reptilian dentition, serves as a putative niche for tissue-resident epithelial stem cells and recent molecular findings from transcriptomics carried out in reptilian dentitions. We discuss how odontoclasts

clear the eruption pathway and allow shedding of functional teeth. The reptiles, particularly lizards, are emerging as some of the most accessible animals to study tooth replacement which has relevance to evolution of the dentition and human dental disorders.

Ebani, V.V. (2024). Staphylococci, reptiles, amphibians, and humans: What are their relations? *Pathogens* 13(7) (<https://doi.org/10.3390/pathogens13070607>).

Abstract: Reptiles and amphibians are largely present in many environments, including domestic areas when they are kept as pet animals. They often harbor zoonotic pathogens, which can pose a serious risk of infection for humans, mainly immunocompromised individuals, the elderly, children, and pregnant women. Several studies have been carried out to verify the role of cold-blooded animals in the epidemiology of some bacteria, mainly *Salmonella*, whereas scarce attention has been focused on these animals as a source of staphylococci. These bacteria are often antimicrobial-resistant and they act as opportunistic pathogens, which can cause relevant infections in humans and animals, both domestic and wild. Asymptomatic reptiles and amphibians often harbor staphylococcal strains, such as *Staphylococcus aureus* and coagulase-negative *Staphylococcus* spp.; however, these bacteria have been associated with clinical conditions that usually appear in animals under stress conditions. In all cases, greater attention should also be focused on staphylococci in cold-blooded animals due to their implications in human and veterinary medicine.

Bar, S., Singh, S., Dhara, S., Das, A.K., Justin, J., Ghosh, D., Madhu, N.R. and Ghorai, S.K. (2024). The dual nature of wildlife of Indian Sundarbans: Cooperation and conflict. Pp. 1-34 in *Life as Basic Science: An Overview and Prospects for the Future, Volume 2*, ed. by S. Das, L. Appleton, J.K. Das and M. Das. International Academic Publishing House: UK.

Abstract: The Sundarbans act as home to diverse groups of wildlife and provide livelihoods for millions of people present in Sundarbans. The wildlife and human populations are closely associated with each other in this vulnerable ecosystem that is marked by complex ecological interactions with dependencies and conflicts. This article provides a brief overview of the dependencies of the local people of Sundarbans and the conflicts associated with it. Local people are involved in various types of activities like fishing, crab collection, honey collection, firewood collection, etc. Human activities are the major causes of the conflicts with wildlife in this area. The major focus of conflict is the Royal Bengal Tiger and crocodile being a potential threat to human life. The dependencies and conflicts between humans and wildlife need a balanced approach to conservation and development.

Ghasemi, Z.Z. (2024). Evaluation of the effects of development of Gando protected area by rapid impact assessment matrix method (RIAM). *Environment, Development and Sustainability* (<https://doi.org/10.1007/s10668-024-05204-1>).

Abstract: The short-nosed crocodile or swamp crocodile is distributed from Iran to Assam, India. Evaluating the effects of development is a way to show the negative and positive effects of a project and thus a tool for proper planning and optimal management. The purpose of this study is to evaluate the development effects of Gando Protected Area using Matrix (rapid impact assessment matrix). Research results show that highway construction has fewer negative consequences and more positive effects. In stage (RIAM-A) of the highway, there are 2 positive effects, of which 2 slightly positive, 7 unchanged, 8 negative and 3 moderate, while in option (RIAM-B) there are 5 positive, 5 small positive effects, 10 small negative effects and 3 moderate negative effects. It has had positive economic, social and cultural effects and has led to an increase in the satisfaction of the residents of the region and

neighboring areas. The scoring of parameters in the RIAM method is more accurate due to its consideration of sustainability criteria, reversibility, and accumulability of impacts. This method enables a more realistic evaluation of development impacts, taking into account the biological value of this animal as an ecosystem regulator, which enhances the assessment.

Cherlin, V.A. (2024). The unique morphofunctional structure of the reptilian heart. *Biology Bulletin Reviews* 14: 466-476.

Abstract: The paper analyzes the evolution of the thermoenergetic statuses of vertebrates and the associated evolutionary development of their heart. The analysis shows that, in most modern lepidosaurs and turtles, the heart is not completely, conditionally five-chambered: it has two atria and one ventricle, in which two incomplete septa divide it into three functional chambers. In some of them, these two septa were modified in evolution so that they turned into one with vertical and horizontal elements, as a result of which the heart became functionally four-chambered, with improved separation of arterial and venous blood flows. Crocodiles have a fully morphologically four-chambered heart. But the hearts of all reptiles, both recent and extinct, perform two opposite functions in parallel - the separation of arterial and venous blood flows and at the same time their regulated mixing. To do this, there are special morphological and physiological mechanisms in their hearts. Such a strange functional duality in the work of the reptilian heart aims to regulate the metabolism level by controlling the amount of carbon dioxide entering the blood flow: increasing the amount of CO₂ in the blood flow reduces the metabolic rate; reducing its amount increases the metabolism. Mixed blood in the blood flow of reptiles is not an immature, primitive state, but a physiological necessity. Moreover, this method of regulating the metabolic rate is most adequate to the initial, ancestral thermoenergetic state in reptiles, because basal terrestrial tetrapods and most ancient reptiles were meso- and even tachymetabolic, ie almost or completely warm-blooded, endothermic animals. It was just these endothermic animals that needed such type of metabolism regulation. As a result, all recent reptiles have a complex morphophysiological organization of the heart, which was functionally more suitable for their almost warm-blooded ancestors. Recent reptiles use part of their ancestral properties as an adaptation to new environmental conditions, new environmental requirements, and their new morphophysiological state. This unique organization of the heart is characteristic of all modern and extinct reptiles, and, importantly, it is characteristic exclusively of reptiles owing to their original endothermic state.

Buffetaut, E. (2024). Franz Nopcsa's researches on French palaeontological collections. *Historia Natural* 14(1): 31-51.

Abstract: An often overlooked aspect of the palaeontological researches of Franz Nopcsa (1877-1933) is his work on various fossil vertebrates kept in French institutions. Although Nopcsa disliked the French, he travelled to France on several occasions, both before and after World War I, to study specimens in Paris, Le Havre, Lyon and Marseille (and possibly Boulogne-sur-mer). His publications on material in French collections include papers on Cretaceous turtles, Cretaceous and Eocene crocodilians and Jurassic and Cretaceous dinosaurs. His work on armoured dinosaurs, including a Late Jurassic partial stegosaur skeleton from Normandy and Late Cretaceous ankylosaur remains from southern France, are especially significant because he correctly interpreted specimens that had previously been misidentified by French palaeontologists. Although they form a relatively small part of his considerable scientific production, these studies were valuable contributions to our knowledge of French Mesozoic vertebrates.

Resumen: Un aspecto a menudo no considerado de las investigaciones paleontológicas de Franz Nopcsa (1877-1933) es su trabajo sobre diversos vertebrados fósiles conservados en instituciones francesas. Aunque a Nopcsa no le agradaban los franceses, viajó a Francia en

varias ocasiones, tanto antes como después de la Primera Guerra Mundial, para estudiar especímenes en París, Le Havre, Lyon y Marsella (y posiblemente Boulogne-sur-mer). Sus publicaciones sobre material de colecciones francesas incluyen artículos sobre tortugas del Cretácico, cocodrilos del Cretácico y Eoceno y dinosaurios del Jurásico y Cretácico. Su trabajo sobre dinosaurios acorazados, incluyendo un esqueleto parcial de estegosaurio del Jurásico tardío de Normandía y restos de anquilosaurios del Cretácico tardío del sur de Francia, son especialmente significativos porque interpretó correctamente especímenes que previamente habían sido identificados erróneamente por paleontólogos franceses. Aunque forman una parte relativamente pequeña de su considerable producción científica, estos estudios constituyen valiosas contribuciones a nuestro conocimiento de los vertebrados mesozoicos franceses.

Esizimotor, E.E. (2024). The little sculptures of Kemwin-Kemwin artists. *AWKA Journal of Fine and Applied Arts* 10(1): 46-57.

Abstract: The tradition of apothecary in Benin may be as old as the need for medication itself and kemwin-kemwin sellers are those who trade in apothecary. Their relics include the skulls of dead animals, bones of alligator, bones of dogs, snakes or lizards, cowries, calabashes, clay pots of different sizes, little molded figures in clay or laterite, live chicks, live tortoise, pumpkin pods, cotton fabric of red, black and white colours, mirrors and many more odds and ends. This is a possible choice for the name kemwin-kemwin that could be translated to 'bits and pieces' or 'this and that'. Many researchers have written on apothecary but not very few have focused on the craft of sculpture done by these kemwin-kemwin traders. Very soon the tradition of kemwin-kemwin may become moribund as most traders and artists, are affected by a possible decline in patronage. The study is aimed at popularizing and cataloguing kemwin-kemwin figurines as part of the collection of reliquaries by kemwin-kemwin market women practitioners. The researcher described their cultural significances, religious and decorative functions to the buyers and users of these figurines.

Gray, K.L., Brereton, J.E. and Theodorou, A. (2024). Does zoo visitor presence and noise impact the behaviour and enclosure use of zoo-housed Siamese crocodiles? A case study. *Journal of Zoo and Aquarium Research* 12(3): 145-153.

Abstract: Investigations of captive reptile behaviour and welfare indicators are essential if management styles are to be advanced. Humans are an integral part of the zoo environment and are a factor to consider when evaluating animal behaviour and welfare. Although crocodilians have been kept in zoos worldwide for decades, there is limited research on captive individuals. As crocodilians are naturally sensitive to sound, the noise that zoo visitors generate has been suggested to affect how individuals behave and use their environment. This project investigated the behaviour and enclosure use of a pair of Siamese crocodiles *Crocodylus siamensis* in order to quantify their response to zoo visitor presence and noise output. Camera traps were used to record the behaviour of the crocodilians across 24-hour time periods. The sampling technique applied was an instantaneous focal sampling method with two-minute intervals for state behaviour and an Electivity Index was applied to measure enclosure use of biologically relevant zones within the enclosures. The results identified that several variables were significant predictors of crocodilian behaviour, including ambient temperature, individual, time of day, visitor numbers and ambient noise (dB). Additionally, correlation analysis found that visitor numbers and ambient noise had only a weak, significant positive correlation ($r = 0.298$, $P = 0.017$). Most zones within the enclosure were underutilised by the crocodiles apart from zone 3 (the water bank). This demonstrates that hauling out areas between land and water (haul-out zones) may be of great value to the study crocodiles and it is therefore expected that these areas would be over-used. There is considerable scope for future research on crocodiles in zoos

focusing on the biological differences between crocodiles that may affect sensitivity to visitor presence.

Brandoni, D., Schmidt, G.I., Bona, P., Tarquini, J., Vlachos, E. and Noriega, J.I. (2024). New vertebrates from the Ituzaingó Formation (Late Miocene of Entre Ríos Province, Argentina), including first records of *Leptodactylus* (Amphibia, Anura) and *Chelonoidis* (Testudines, Cryptodira). Historical Biology (<https://doi.org/10.1080/08912963.2024.2379039>).

Abstract: The Late Miocene vertebrate fauna from the Entre Ríos Province, Argentina, comes from two units: the marine Paraná Formation and the Lower Member of Ituzaingó Formation (LMIF). This latter includes a lower conglomerate set, with fine quartz gravel, and clay and chalcedony clasts, and fossil remains, traditionally known as ‘Mesopotamiense’ or ‘Conglomerado osífero’. We present new fossil vertebrate remains from the LMIF at the Puerto Víboras locality (Hernandarias, Entre Ríos Province) including *Leptodactylus* sp. (Amphibia, Anura), *Crocodylia* indet. (Caimaninae indet. and *Paranasuchus gasparinae* (Alligatoridae), Chelidae indet. (Testudines, Pleurodira), *Chelonoidis* sp. (Testudines, Cryptodira), *Plohophorus paranensis* (Cingulata, Glyptodontidae), and *Macraucheninae* indet. (Macrauchenidae, Litopterna). The record of *Leptodactylus* sp. represents the oldest record of the genus and the first amphibian record for the Neogene of the Entre Ríos Province. The material described herein and assigned to *Chelonoidis* sp. allows to confirm for the first time the presence of a testudinid in the Late Miocene of the Entre Ríos Province.

Massonne, T. (2023). The Crocodylian, Bird and Turtle Fauna from the Late Eocene Na Duong Basin of Vietnam. PhD thesis, Eberhard Karl University of Tübingen, Tübingen, Germany.

Summary: At the end of the Eocene, there was a major cooling of the Earth, which subsequently led to a great mass extinction, the so-called ‘Grande Coupure’. To learn more about the faunal exchange during this extinction event, fossil ecosystems, especially those that existed immediately before and after the cooling at the end of the Eocene, are of enormous importance. The Na Duong Basin in northeastern Vietnam is ideally suited for such a study. The basin is now an active open-cast coal mine, but in the late Eocene it contained small ponds that were in transition to an anoxic lake. A large number of well-preserved fossils of many different plant and animal species have been found in the Na Duong Basin. However, as very little is known about the reptiles and birds of the basin, an important piece of the puzzle to reconstruct this ecosystem was still missing. The main objective of this thesis was therefore to add to the existing knowledge on this aspect. However, the results have not only had the expected impact on the knowledge of the Na Duong Basin as such, but have also improved our understanding of the relationships of crocodylians and turtles of the Palaeogene of East Asia and the ecological connection of three late Eocene basins in Vietnam, Thailand and China. The first project focused on several individuals of a small alligatoroid of just under 2 m in length. After the description of the material and an intensive phylogenetic analysis, it was possible to show that the fossil was a new species (*Orientalosuchus naduongensis*) and that *O. naduongensis* was the missing link to unite a total of six species that lived in East Asia from the Cretaceous to the Eocene into a new clade: Orientalosuchina. Within this group, the closest relatives of *O. naduongensis* were species from the two late Eocene basins of Maoming (China) and Krabi (Thailand). The results of the phylogeny also allow conclusions to be drawn about the distribution of early alligatoroids at the end of the Cretaceous. The second project of the thesis focused on the apex predator of the Na Duong Basin, a tomistomine about 3.5 m long. The new species (*Maomingosuchus acutirostris*) was placed in the genus *Maomingosuchus* after a detailed description of the holotype, an almost completely preserved individual, and a comparison with fossil members of the group. Previously, this genus was only known from the Maoming and Krabi basins. The

phylogenetic analysis also revealed a much more basal position of *Maomingosuchus* than previously postulated. The new result correlates much better with the age of the genus and also allows the conclusion that representatives of the tomistomines must have reached East Asia at least three times independently of each other. The third project focused on a tarsometatarsus from an unknown chicken-sized bird species, which was described and compared with extant specimens. The characteristic appearance of the bone is not comparable with any known species. The fossil is one of the few known birds from the Palaeogene of East Asia the only one from the Palaeogene of Vietnam. Thus, despite its incompleteness and relatively poor preservation, the fossil makes an important contribution to our knowledge of the Palaeogene avifauna of East Asia. The last project described several individuals of a new species of Pan-Trionychidae named *Striatochelys baba*. The species is a relatively small representative of Pan-Trionychidae with a carapace length of slightly less than 30 cm. Comparison with extant and fossil representatives of the group as well as a phylogenetic analysis suggests a relationship with the purely Asian extant genus *Nilssonina*. However, *S. baba* shows the greatest similarity to a fossil species from the Maoming Basin. The results of the thesis show that the three East Asian basins of Na Duong, Maoming and Krabi had a closely related crocodylian and turtle fauna. Representatives of Orientalosuchina and the genus *Maomingosuchus* were found in each of these basins, and the turtle genus *Striatochelys* was represented at least in Na Duong and Maoming. These results indicate that at some point in the Palaeogene there must have been a connection between the three basins, allowing faunal exchange. On the other hand, the results also suggest that either there must have been some kind of physical barrier before the end of the Eocene that allowed the basins to be separated and resulting in the divergence of the herpetofauna. Alternatively, the closely related species may be chronospecies. With regard to the faunal exchange of the Reptilia groups studied, a definite conclusion is limited by the lack of East Asian assemblages that can be dated with certainty immediately after the ‘Grande Coupure’. Orientalosuchina occur only from the Late Cretaceous to the late Eocene, but are absent from Miocene assemblages, possibly indicating, that this group did not survive the ‘Grande Coupure’ and was possibly replaced by the genus *Alligator*, which dispersed from North America towards Asia around this time. Tomistomines have survived to the present day, but the *Maomingosuchus* lineage is not found in Miocene assemblages, instead much larger tomistomines such as *Penghusuchus pani* are present in East Asia at this time, probably from a second dispersal event from Europe. *Striatochelys baba* may represent a stem member of the extant *Nilssonina*, as indicated by direct comparison with extant species and the phylogenetic analysis. If this is true, this species or close relatives survived the cooling at the beginning of the Oligocene. Unfortunately, the bird fossil is too poorly preserved and other fossils from East Asia are too sparse to draw any conclusions about its survival of the ‘Grande Coupure’.

Takahashi, K., Lee, Y., Fago, A., Bautista, N.M., Storz, J.F., Kawamoto, A., Kurisu, G., Nishizawa, T. and Tame, J.R.H. (2024). The unique allosteric property of crocodilian haemoglobin elucidated by cryo-EM. Nature Communications 15(1) (<https://doi.org/10.1038/s41467-024-49947-x>).

Abstract: The principal effect controlling the oxygen affinity of vertebrate haemoglobins (Hbs) is the allosteric switch between R and T forms with relatively high and low oxygen affinity respectively. Uniquely among jawed vertebrates, crocodilians possess Hb that shows a profound drop in oxygen affinity in the presence of bicarbonate ions. This allows them to stay underwater for extended periods by consuming almost all the oxygen present in the bloodstream, as metabolism releases carbon dioxide, whose conversion to bicarbonate and hydrogen ions is catalysed by carbonic anhydrase. Despite the apparent universal utility of bicarbonate as an allosteric regulator of Hb, this property evolved only in crocodilians. We report here the molecular structures of both human and a crocodilian Hb in the deoxy and liganded states, solved by cryo-electron microscopy.

We reveal the precise interactions between two bicarbonate ions and the crocodilian protein at symmetry-related sites found only in the T state. No other known effector of vertebrate Hbs binds anywhere near these sites.

Dewi, T.R., Rahmatlengkadjaya, Oktadiana, H. and Arafah, W. (2024). Review of the use of crocodile bread in traditional Betawi wedding ceremonies: Traditions, meaning and influence on local cultural development. *International Journal of Education, Business and Economics Research* 4(4): 133-142.

Abstract: This research aims to reveal the symbolic meaning of crocodile bread in traditional Betawi wedding ceremonies, analyze its impact on the development of local culture, and highlight the evolution of this symbolism in facing the challenges of globalization. The research method used is a qualitative approach with case studies to explore the practice of using crocodile bread and its symbolic meaning in depth. The research results show that crocodile bread is not just a decorative object but a symbol that carries meaning about fertility, reporting, and family unity in Betawi society. Its use is not only to maintain local cultural identity but also as an effort to preserve traditional values amidst globalization. In conclusion, crocodile bread plays a vital role in maintaining and developing Betawi culture, while its adaptation to changing times reflects the origins of a relevant and sustainable culture. This research suggests that further efforts are needed to promote and understand the symbolic values of crocodile bread to maintain Indonesia's cultural heritage in the modern era.

Markwell, K. (2024). Protecting “the unpopular ones.” Conservation themes in the writings of naturalist/herpetologist, Eric Worrell. *Australian Zoologist* (<https://doi.org/10.7882/AZ.2024.027>).

Abstract: Australian naturalist and herpetologist, Eric Worrell (1924-1987), established the Australian Reptile Park at Wyoming on the NSW Central Coast in 1959. While the Park gave him a prominent platform as a popular reptile expert, his authority was also constructed through his publications. He was a prodigious writer: 11 books and more than 100 articles on aspects of natural history, as well as other topics, in popular magazines such as *Outdoors* and *Fishing, People, Walkabout* and *Wild Life*. Worrell also published in scientific journals including *Proceedings of the Royal Zoological Society of NSW*, *Australian Zoologist* and *Western Australian Naturalist*. Using thematic and content analyses, this article identifies and explores key themes relating to the conservation of Australia's reptile fauna, or what Worrell referred to as “the unpopular ones”, in his writings. Four dominant themes, with some overlap, were identified and it was found that Worrell's approach to reptile conservation was overwhelmingly pragmatic, based on the communication of factual evidence, derived in large part from his own direct experiences with reptiles.

Vyas, R., Chauhan, D., Vaghashiya, P. and Patel, H. (2024). Noteworthy observations on food and feeding behaviors of mugger crocodiles (*Crocodylus palustris* Lesson) at Lal Dhor, Girnar Wildlife Sanctuary, Gujarat, India. *Journal of Animal Diversity* 6(1): 1-11 (<http://dx.doi.org/10.22034/JAD.2024.6.1.1>).

Abstract: Mugger Crocodiles (*Crocodylus palustris*) are apex predators of freshwater aquatic ecosystems throughout South Asia whose natural history and ecology are incompletely known. We present some noteworthy observations on feeding behavior, hunting strategy, and diet of the species based on seven observations during the last four years as part of a long-term monitoring study in Junagadh, Gujarat, India. We found Muggers of this region feeding on the domestic dog (*Canis familiaris*), Indian rock python (*Python molurus*), Indian flap-shelled turtle (*Lissemys punctata*), several species of fishes, as well as cannibalism events. Moreover, we review and discuss some published observations of the species.

Tettamanti, G., Curto, L., Obligado, E., Vera, D.G., Sierra, E.A., Velasco, M.A. and Kacoliris, F.P. (2024). Occurrence of *Caiman latirostris* and *Caiman yacare* in the Middle Delta of the Paraná River, Argentina. *The Herpetological Bulletin* 168: 20-22.

Abstract: In Argentina, there are two species of the Crocodylia group, both belonging to the Alligatoridae family. The black caiman (*Caiman yacare*) is found in the provinces of Chaco, Corrientes, Formosa, Misiones, Salta, and Entre Ríos. The other species, the broad-snouted caiman or flat-faced caiman (*Caiman latirostris*) inhabits Chaco, Corrientes, Entre Ríos, Formosa, Jujuy, Misiones, Salta, Santa Fe, and Santiago del Estero (Prado *et al.* 2012). Both species were listed as Least concern in the IUCN Red List (Siroski *et al.* 2020, Campos *et al.* 2020). Historically, there have been anecdotal records of both species in various localities of the Middle Delta of the Paraná River in the north of Buenos Aires (Chebez 2008). Restivo *et al.* (2011) mention that caimans occasionally use rivers for dispersal, thus reaching more southern latitudes than usual for them. They add that these are generally adult individuals, often males that move south in the summer, but it is unknown if they manage to survive the winter. The objective of this work was 1) record alligator occurrences in the Middle Delta of the Paraná River during the extraordinary downturn of the Paraná River that occurred between 2020 and 2022 and 2) confirm the winter survival of alligators in this area.

Hinay, Jr., A.A., Cadotdot, N.M.T., Tablizo, M.V. and Francisco, A.F. (2024). Anti-HIV activity of Philippine crocodile (*Crocodylus mindorensis*) serum on infected human mononuclear cells. *Acta Microbiologica Hellenica* 69: 180-186.

Abstract: The search for effective inhibitors of HIV-1 replication remains a critical research area of research in virology and immunology. Natural products have emerged as promising candidates for antiviral therapies. In the present study, we assessed the potential inhibitory activity of Philippine crocodile serum at both pre- and post-infection stages of the HIV-1 replication cycle. Freshly collected crocodile serum samples were used in a cell culture-based assay with peripheral blood mononuclear cells. HIV-1 reverse transcriptase activity in the treated cell culture system was assessed using colorimetric enzyme immunoassay. The crocodile serum at 0.5% and 0.25% vol/vol concentrations showed an inhibitory activity against HIV-1 replication both in pre-infection interactions ($68.61 \pm 1.67\%$ and $69.95 \pm 2.24\%$, respectively) and post-infection interactions ($65.68 \pm 2.93\%$ and $69.92 \pm 0.45\%$, respective). These findings suggest that Philippine crocodile serum may have potential as a natural inhibitor of HIV-1 replication and warrant further investigation into its therapeutic use.

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 the corticosterone:DHEA ratio in farmed crocodiles before and after an acute stressor. *Animals* 14: 2236.

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 (CORT), 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 the baseline. Downstream effects of these catecholamines and CORT appear to be associated with a persistent increase in plasma glucose and HLR. Lactate also showed acute fluctuations over time but returned to the baseline by the final measurement. DHEA, which is used in a ratio with CORT, 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 our understanding of crocodilian stress and potentially informing improved farming practices for conservation and sustainable management.

Cartes Yegros, J.L., Santacruz, M., Gómez, D., Ferreira Riveros, M., Del Castillo, H., Sforza, L., Rivas, D. and Cacciali, P. (2024). Analysis of patterns related to wildlife roadkill in the Humid Chaco of Paraguay. *One Ecosystem* 9: e127214.

Abstract: Paved roads are a solution for communication between human societies, but at the same time, their expansion is detrimental to wildlife. In this work, vertebrate mortality events due to traffic collisions on National Route N° 5, in a 50 km stretch from the town of Pozo Colorado to the east, are evaluated. Vehicle journeys were carried out at a constant speed of 40 km/h every two months, from November 2020 to May 2022. All findings of roadkill were recorded by photograph. To analyse spatial patterns, the Kernel density was estimated, assessing the randomness of Ripley's K collisions and standardised roadkill rates were assessed for each species. A total of 272 individuals were recorded, corresponding to 87 amphibians, 38 birds and 35 mammals. In terms of the number of species, the composition was as follows: reptiles with 20 species, birds with 13 species, mammals with 11 and amphibians with at least 12 species. The species with the highest number of dead individuals was the common toad (*Rhinella diptycha*), followed by snakes. According to the standardised roadkill rates, the most affected animals are *Cerdocyon thous*, *Rhinella diptycha*, *Caiman yacare* and *Dryophylax hypoconia* with more than 200 individuals per kilometre per year. A bat, *Lasiurus ega*, was identified for the first time for Paraguay. Climatic conditions seems to have no strong effect on the occurrence pattern of the different taxa, with the exception of birds that decrease with stronger winds. The greatest coincidences occurred in three sections: km 5-5.5, km 33.5-34.5 and km 40-43. There was a correlation with crossroads areas, watercourses and forest islands. In view of the road development policy in the region, it is necessary to carry out studies of its impacts in the longer term.

Ohwo, O.A., Gbigbi, T.M., Agidi, C.H. and Dolor, D.E. (2024). Factors determining farmers' adoption of cultural practices for forest resources conservation in Delta State, Nigeria. *Local Environment* (<https://doi.org/10.1080/13549839.2024.2386967>).

Abstract: Studies on conservation of forest resources abound but the application of cultural practices is being neglected. The use of the logit regression model in identifying the factors that influenced the adoption of these cultural practices was a milestone in this work. The goal of the study was to identify existing cultural practices of conservation and factors that influenced its adoption. Key informants for the study were obtained using multi-stage selection techniques. Information on cultural practices, forest resources conserved by these practices and groups within the community responsible for implementing these practices were obtained using a structured questionnaire and interview schedule. Descriptive statistics and a logistic regression model were used. The study bared that males (70.4%) dominated. The practice of sacred grooves, forbidden forest resources, festive harvesting, ancestral beliefs and restriction from felling trees of ancestral origin was used in conserving snakes, crocodiles, *Millicia excelsa*, *Achatina achatina*, *Tyto alba*, *Neuboudia laevis*, *Irvingia wombulu* in the communities. The factors influencing the adoption of these practices were education, age of the respondent, native of the community and religion. The traditional head, traditional executives, chief priest and sometimes,

the whole community enforced and implemented these beliefs and proscribed penalties for defaulters. Cultural practices that support the wise use of resources from the forest are still in existence and effective. The collaboration of the State Forestry division with these communities in harnessing their cultural practices is vital to the quest of conserving these diverse species in the forest.

Lindshield, S., Ndiaye, P.I., Walters, A. and Bogart, S.L. (2024). A survey of nocturnality and risk for savanna chimpanzees at Assirik, Senegal. *Folia Primatologica* (<https://doi.org/10.1163/14219980-bja10032>).

Abstract: Chimpanzees (*Pan troglodytes*) in Senegal may use nocturnality to mitigate hyperthermia risk in semi-arid environments but the degree of nocturnality for such chimpanzees also in sympatry with large carnivores remains uncertain. We compared diel activity among chimpanzees and their potential predators at Assirik in Niokolo-Koba National Park and contextualized these findings relative to other unit-groups in savanna landscapes. From 2015-2018, we generated a predator inventory using multi-modal methods and monitored the diel activity of chimpanzees and predators with camera traps [N= 2092 camera trap (CT) days]. From 2015-2023, we also surveyed for evidence of predation during recce walks. Six potential nonhuman predators occur at Assirik, including lions (*Panthera leo*), leopards (*Panthera pardus*), spotted hyenas (*Crocuta crocuta*), African wild dogs (*Lycaon pictus*), Nile crocodiles (*Crocodylus niloticus*), and rock pythons (*Python sebae*). We documented one suspected case of a predator killing a chimpanzee. Nocturnality comprised 12.7% of CT events for chimpanzees and these events were more concentrated at twilight. Chimpanzees were more active during the day, predators were more active at night, and there was substantial temporal overlap among chimpanzees and potential predators during twilight intervals. Our findings support the hypothesis that savanna chimpanzees in Senegal are active at night in response to the extremely hot environment. We hypothesize that Assirik chimpanzees experience a tension between decreasing hyperthermia and increasing predation risk during nocturnality.

Fernández-Dumont, M.L. (2024). Juvenile notosuchian crocodiles from the La Buitrera Paleontological area with comments on qualitative ontogenetic characters. *Historical Biology* (<https://doi.org/10.1080/08912963.2024.2383715>).

Abstract: *Araripesuchus* is a genus of medium-sized (approximately 1 m long) terrestrial uruguaysuchid crocodyliforms that lived during the Cretaceous in Gondwana. There is limited information about juvenile notosuchian specimens due to the scarcity of well-preserved fossils from ontogenetic series. This study presents a comprehensive morphological description of three juvenile specimens of *Araripesuchus* (MPCA PV 259, 624, and 1193) from the La Buitrera Paleontological Area, Patagonia, Argentina. These early developmental-stage specimens were identified at a generic level due to the absence of mature anatomical characters for precise classification. Variations were observed between these juveniles and the previously examined adult specimens from the same region. As a result, a list of characters indicating ontogenetic variants was provided. These characters represent discrete traits that vary throughout the life of the individuals and could serve as ontogenetic indicators. This study offers a deeper understanding of the skeletal anatomy of *Araripesuchus* and its range of morphological variation, providing new data for the characterisation of the genus and potential new taxa of uruguaysuchids.

Pinheiro do Val, H.G., Souza do Vale, C.A., Figueiredo Passos, L. and Coutinho, M.E. (2024). Intraspecific variation in Black caiman (*Melanosuchus niger*) embryonic development. *Reptiles & Amphibians* 31: e18981.

Abstract: Steps in the embryonic development of crocodilians are

usually species-specific, highlighting the plasticity of the process. Herein we describe intraspecific variation in the growth of embryos in three Black caiman (*Melanosuchus niger*) nests monitored *in situ* in the Central Brazilian Amazon. Nests differed in which embryonic stages the first increases in total length and mass occurred. Differences from a previous study of the same species included the timing of morphological characteristics such as the closure of the abdominal wall. Therefore, our data are indicative of the plasticity of embryonic development of Black caimans in natural conditions.

González-Desales, G.A., Soria-Ortiz, G.J., Monroy-Vilchis, O., Zarco González, Z. and Charruau, P. (2024). Prevalence of injuries in a *Caiman crocodilus chiapasius* (Bocourt 1876) population from the South Pacific coast of Mexico. *Studies on Neotropical Fauna and Environment* (<https://doi.org/10.1080/01650521.2024.2380162>).

Abstract: Crocodilians injuries are indicators of their health and social interactions. We analyzed the prevalence and distribution of injuries in spectacled caiman (*Caiman crocodilus chiapasius*) from the Biosphere Reserve of La Encrucijada (BRLE) in relation to the habitat, size, and sex of individuals. We collected data on injuries in caimans captured during nocturnal surveys (2014-2022) in the estuary and swamps of the BRLE. We determined the sex of each caiman, measured their snout-vent length, and registered the type of injury and body region where injuries were detected. From all records, 102 of 301 caimans (33.9%) presented injuries and they were more likely to be injured in the estuary than in the swamps, probably due to the presence of a larger sympatric crocodile species in the estuary (*Crocodylus acutus*). Sex had no effect on the proportion of injured individuals, but larger caimans have a higher probability of being injured than smaller ones, explained by an ontogenetic change in the individuals' behaviors. Habitat, sex, and size class of individuals do not influence the number of injuries on different body regions. The tail was the most injured body region (17.6% of individuals), followed by the abdomen (13.0%), back (12.6%), head (9.6%), and extremities (4.0%).

Ito, K., Kinugasa, T., Okoshi, T., Kimura, K., Chiba, K., Takasaki, R., Ideraikhani, D., Hayashi, R., Yoshida, K. and Osuka, K. (2024). Can dinosaurs' hindlimbs maintain their stance posture using the passive interlocking mechanism confirmed in crocodilian hindlimbs? Pp. 62-67 in AROB-ISBC-SWARM 2024, Beppu, Japan.

Abstract: This report addressed the stance mechanism in a non-avian dinosaur *Protoceratops andrewsi* hindlimbs using a robotic approach. Our previous studies demonstrate the passive interlocking mechanism in crocodilian hindlimbs is crucial to achieving their standing motion. We verified the importance of the passive mechanism by implementing artificial musculotendinous systems, following the inference derived from crocodilians, onto a 3D printed physical model of the *Protoceratops* skeleton. The experiments validated the feasibility of achieving the stance posture of *Protoceratops* through the interaction between the artificial musculoskeletal tendinous system and ground reaction forces in a similar manner to crocodilians. This report highlights constructing a physical model with artificial musculotendinous systems is a valuable platform for exploring locomotion in extinct animals.

Ward-Fear, G., Bruny, M., The Bunuba Rangers, Forward, C., Cooksey, I. and Shine, R. (2024). Taste aversion training can educate free-ranging crocodiles against toxic invaders. *Proceedings of the Royal Society B: Biological Sciences* 291(2028) (<https://doi.org/10.1098/rspb.2023.2507>).

Abstract: Apex predators play critical ecological roles, making their conservation a high priority. In tropical Australia, some populations of freshwater crocodiles (*Crocodylus johnstoni*) have plummeted by greater than 70% due to lethal ingestion of toxic invasive cane toads (*Rhinella marina*). Laboratory-based research has identified

conditioned taste aversion (CTA) as a way to discourage consumption of toads. To translate those ideas into landscape-scale management, we deployed 2395 baits (toad carcasses with toxin removed and containing a nausea-inducing chemical) across four gorge systems in north-western Australia and monitored bait uptake with remote cameras. Crocodile abundance was quantified with surveys. Free-ranging crocodiles rapidly learned to avoid toad baits but continued to consume control (chicken) baits. Toad invasion at our sites was followed by high rates of crocodile mortality (especially for small individuals) at a control site but not at nearby treatment sites. In areas with high connectivity to other waterbodies, repeated baiting over successive years had continuing positive impacts on crocodile survival. In summary, we succeeded in buffering the often-catastrophic impact of invasive cane toads on apex predators.

Treeprapin, K., Kaewtip, K., Singchat, W., Ariyaratpong, N., Panthum, T., Duengkakae, P., Temsiripong, Y., Srikulnath, K. and Trirongjitmoah, S. (2024). Transforming crocodile traceability: Deep metric learning for identifying Siamese crocodiles. *Ecological Informatics* (<https://doi.org/10.1016/j.ecoinf.2024.102771>).

Abstract: This study introduces a novel method for identifying individual Siamese crocodiles (*Crocodylus siamensis*), which is a crucial requirement for conservation and sustainable industry practices. Although deep metric learning (DML) has improved identification model robustness and reduced dependency on large datasets, comprehensive field studies and long-term deployments are lacking. To address this, DML combined with convolutional neural network (CNN) was applied for enhancing accuracy using a limited and imbalanced number of images per class and distinguishing dissimilar scale patterns of the head and ventral regions. Individual crocodiles were identified using the k-nearest neighbor (KNN) and support vector machine (SVM) classifiers based on the extracted features. Data were collected from 30 individuals on a crocodile farm using photographs taken over two consecutive years. Two identification types, Type 1, based on a model trained on images collected over two years; and Type 2, based on a model trained exclusively on images from the first year, were implemented. Type 1 identification, which used a CNN combined with the KNN and SVM classifiers, exhibited an accuracy exceeding 99.75 and 92.93% for the ventral and head regions, respectively. Type 2 identification exhibited a reduced accuracy because of a comparatively smaller amount of learning information; the proposed CNN achieved 83.99% accuracy for ventral identification and 67.14 and 65.61% for head identification with KNN and SVM, respectively. This study underscores the efficacy of DML and CNN for handling small, imbalanced datasets in identifying individual crocodiles, and has significant implications for traceability and conservation initiatives in the crocodile industry.

Han, D., Fuquen, R., Willis, K.L., Christensen-Dalsgaard, J. and Carr, C.E. (2024). Sound localization circuits in reptiles. *Frontiers in Amphibian and Reptile Science* 2 (<https://doi.org/10.3389/famrs.2024.1429172>).

Abstract: Location of sound sources is a fundamental task of the auditory system. Recent studies have shown that land vertebrates employ different sound localization strategies. We have therefore compared auditory brainstem circuits by measuring cell numbers in the cochlear nuclei in relation to brain weight among different groups of reptiles to determine if these behavioral differences are reflected in the organization of the brainstem. In extant archosaurs, the birds and crocodilians, the two ears are weakly connected pressure receivers, and sound direction is computed by binaural interactions in brain involving parallel processing of interaural time and level differences. The first-order cochlear nuclei are nucleus magnocellularis (NM) and nucleus angularis (NA). NM projects bilaterally to the nucleus laminaris (NL), where interaural time differences are computed in archosaurs. Relative to brain size, NA, NM and NL cell counts of the American alligator (*Alligator*

mississippiensis) are similar to those of birds. Testudines (turtles and tortoises), sister group to archosaurs, are also assumed to compute sound location from binaural interactions in the brain due to weakly connected middle ears. Compared to archosaurs, NA, NM and NL of the red-eared slider (*Trachemys scripta*), common snapping turtle (*Chelydra serpentina*) and Hermann's tortoise (*Testudo hermanni*) are all proportionally small. In lizards, due to the strong internal coupling of the middle ears, the cochlear nerve responses are directional, and interaural time and level differences are co-dependent and frequency dependent, suggesting that the neural processing of sound direction may be different from archosaurs. Compared to archosaurs, NM and NL of the tokay gecko (*Gekko gecko*) and green iguana (*Iguana iguana*) are proportionally small, but NA is well-developed, suggesting a greater importance of the NA pathway for the processing of the high-frequency directional information generated by the coupled ears. Snakes originated from lizard ancestors, but have secondarily lost their eardrums, and their sound localization strategies are unknown. NA and NM of the western ratsnake (*Pantherophis obsoletus*) are proportionally smaller than those of the lizards.

Barragán-Lara, R., García-Grajales, J. and Martínez-Ramírez, E. (2024). Communal egg laying area of the American crocodile (*Crocodylus acutus* Cuvier, 1807) in a tropical lagoon of Oaxaca, Mexico. *Acta Zoológica Mexicana (nueva serie)* 40: 1-15.

Abstract: For crocodylians, successful nesting has an important effect on population dynamics and it is an excellent indicator of how a species adapts to its environment. The choice of the oviposition site and its environmental conditions will influence embryo development and offspring phenotypes. Nesting success for communal egg-laying in crocodylian nests has not been studied in depth. Our aim in this study was to describe the nesting ecology of a communal egg-laying area of the American crocodile (*Crocodylus acutus*) in the Palmasola lagoon on the coast of Oaxaca. Intensive searches around the lagoon were carried out daily to detect signs of nesting activity and identify potential sites for oviposition. We registered 27 nests for the 2018 reproductive season. Twenty-four nests were located divided into five clusters (Communal egg-laying, CEL) and the rest (n= 3) were classified as isolated nests. The most important CEL site found in the study area presented a grouping of 13 nests, with a mean distance between nests of $0.70 \text{ cm} \pm 0.35 \text{ cm S.D.}$, and a mean clutch size of 34.5 ± 7.1 eggs. Our field observation is the first record of communal egg-laying of American crocodile in the Mexican Pacific slope and can be an indicator of active selection of the nesting areas by females of different sizes. Further studies are needed to provide new insights about the ecological and evolutionary consequences of communal egg-laying on the Mexican Pacific coast.

Pritz, M.B. (2024). Glutamic acid decarboxylase immunoreactivity in the olfactory bulb of a reptile. *NeuroReport* (<https://doi.org/10.1097/WNR.0000000000002082>).

Abstract: The objective is to determine the distribution of glutamic acid decarboxylase (GAD) in the olfactory bulb of a crocodylian, *Caiman crocodilus*. Avidin-biotin immunohistochemical methodology using a polyclonal antibody to GAD raised in sheep was employed. The following controls were used: substitution of the primary antibody with preimmune sheep serum at concentrations equal to that of the primary antibody; omission of the primary antibody; and omission of the primary antibody and biotinylated rabbit anti-sheep immunoglobulin. No GAD (+) cells were observed in the control sections. Based on cell and fiber staining, the layering and neuronal organization of the olfactory bulb in *Caiman* were similar to other vertebrates, including other reptiles. The following elements were GAD (+): granule cells, certain neurons in the outer plexiform layer, periglomerular neurons, and the glomeruli themselves. GAD (+) puncta were present throughout the olfactory bulb. In conclusion, these results in *Caiman* were similar, in part, to comparable studies in mammals and birds. Taken together, these

data indicate that crocodiles not only have a similar pattern of layers that other amniotes possess but also that the immunocytochemical signatures of certain elements of the olfactory bulb are likewise shared.

Sun, K., Li, W., Fan, G., Yang, L., Zhang, Z., Shu, Y., Zhou, Y., Tu, G., Zhang, S., Yi, P., Ayub, M., Wu, X. and Pan, T. (2024). Ecological networks of allometric growth, feeding behavior and gut microbiota in Chinese alligator hatchlings. *Asian Herpetological Research* 15(2): 104-114.

Abstract: Chinese alligator hatchlings in captivity are fragile and have a high mortality rate within first year. The body mass gain of reptile animals is closely related to their feeding behavior and gut microbiota. This study analyzed the intrinsic factors influencing the allometric growth of Chinese alligator hatchlings based on their body mass gain, feeding behavior, and gut microbiota. This information would enhance the health management of Chinese alligator hatchlings. There was a significant correlation between the total distance moved, the average number of conspecifics nearby, and body mass gain. Chinese alligator hatchlings with a greater growth rate showed greater activity and more independent behavior during feeding than those with a lower growth rate. Moreover, after feeding started, some functions of the gut microbiota showed significant relationships with growth rate and feeding activity. Chinese alligator hatchlings with a greater growth rate showed greater levels of heme biosynthesis than those with a lower growth rate, and feeding activity was inhibited by long-chain fatty acid biosynthesis. These results elucidate the relationships between health, feeding behavior, and the gut microbiota of Chinese alligator hatchlings. Understanding the intrinsic factors of their health and feeding behavior can improve the health management of Chinese alligator hatchlings in captivity for conservation.

Cubo, J., Sena, M.V.A., Pellarin, R., Faure-Brac, M.G., Aubier, P., Cheyron, C., Jouve, S., Allain, R. and Jalil, N-E. (2024). Integrative paleophysiology of the metriorhynchoid *Pelagosaurus typus* (Pseudosuchia, Thalattosuchia). *The Anatomical Record* (<https://doi.org/10.1002/ar.25548>).

Abstract: Paleophysiology is an emergent discipline. Organismic (integrative) approaches seem more appropriate than studies focusing on the variation of specific features because traits are tightly related in actual organisms. Here, we used such an organismic approach (including lifestyle, thermometabolism, and hunting behavior) to understand the paleobiology of the lower Jurassic (Toarcian) thalattosuchian metriorhynchoid *Pelagosaurus typus*. First, we show that the lifestyle (aquatic, amphibious, terrestrial) has an effect on the femoral compactness profiles in amniotes. The profile of *Pelagosaurus* indicates that it was amphibious, with a foraging activity in shallow marine environments (as suggested by the presence of salt glands) and thermoregulatory basking behavior in land (as suggested by the presence of osteoderms with highly developed ornamentation). As for the thermometabolism, we show that the mass-independent resting metabolic rate of *Pelagosaurus* is relatively high compared to the sample of extant ectothermic amniotes, but analysis of vascular canal diameter and inferences of red blood cell size refute the hypothesis suggesting incipient endothermy. Finally, the foraging behavior was inferred using two proxies. *Pelagosaurus* had a mass-independent maximum metabolic rate and an aerobic scope higher than those measured in the almost motionless *Iguana iguana*, similar to those measured in the sit-and-wait predator *Crocodylus porosus* but lower than those quantified in the active hunter *Varanus gouldii*. These results suggest that *Pelagosaurus* may have had a hunting behavior involving a slow sustained swimming or a patient waiting in shallow waters, and may have caught preys like gharials, using fast sideways sweeping motions of the head.

Rawson, J.R.G., Deakin, W.J., Stubbs, T.L., Smith, T.J., Rayfield, E.J. and Donoghue, P.C.J. (2024). Widespread convergence towards functional optimization in the lower jaws of crocodile-line archosaurs. *Proceedings of the Royal Society B: Biological Sciences* 291(2029) (<https://doi.org/10.1098/rspb.2024.0720>).

Abstract: Extant crocodilian jaws are subject to functional demands induced by feeding and hydrodynamics. However, the morphological and ecological diversity of extinct crocodile-line archosaurs is far greater than that of living crocodilians, featuring repeated convergence towards disparate ecologies including armoured herbivores, terrestrial macropredators and fully marine forms. Crocodile-line archosaurs, therefore, present a fascinating case study for morphological and functional divergence and convergence within a clade across a wide range of ecological scenarios. Here, we build performance landscapes of two-dimensional theoretical jaw shapes to investigate the influence of strength, speed and hydrodynamics in the morphological evolution of crocodile-line archosaur jaws, and test whether ecologically convergent lineages evolved similarly optimal jaw function. Most of the 243 sampled jaw morphologies occupy optimized regions of theoretical morphospace for either rotational efficiency, resistance to Von Mises stress, hydrodynamic efficiency or a trade-off between multiple functions, though some seemingly viable shapes remain unrealized. Jaw speed is optimized only in a narrow region of morphospace whereas many shapes possess optimal jaw strength, which may act as a minimum boundary rather than a strong driver for most taxa. This study highlights the usefulness of theoretical morphology in assessing functional optimality, and for investigating form-function relationships in diverse clades.

Schulz, E.T., Aranha da Costa, E., Dias Lansarin, T., Eucares von Laer, A. and Teresinha França, R. (2025). Anti-*Leptospira* spp. antibody test in noncaptive reptiles from urban and peri-urban areas in Brazil's extreme South. *Ciência Rural* 55(1): e20240067.

Abstract: The state of Rio Grande do Sul has a great diversity of reptile species distributed throughout its territory. Due to human actions, such as habitat fragmentation, these animals have been frequently observed in urban and peri-urban environments. This facilitates the spread of pathogens between animals and humans, posing a unique health risk, as many diseases are considered zoonoses. Leptospirosis is among the most common zoonoses in the world and is caused by pathogenic species of bacteria of the genus *Leptospira*. The role of reptiles in the cycle of this disease is yet unknown. However, serological studies have demonstrated positivity for antibodies against *Leptospira* spp. in tortoises and snakes, which may indicate that these animals act in maintaining the pathogen in the environment. This observed the presence of anti-*Leptospira* antibodies in rescued reptiles taken to the Center for Rehabilitation of Wild Fauna and Screening Center for Wild Animals at the Universidade Federal de Pelotas (NURFS-CETAS/UFPEL). Samples were collected from 55 animals (39 *Trachemys dorbignii*; 3 *Philodryas patagoniensis*; 3 *Caiman latirostris*; 3 *Salvator merianae*; 2 *Acanthochelys spixii*; 2 *Phrynosoma hilarii*; 2 *Hydromedusa tectifera*; 1 *Philodryas aestiva*) from August 2022 to December 2023 and tested for 12 reference serovars. Two animals demonstrated positivity, one for the pathogenic serovar Pyrogenes and the other for the pathogenic serovar Canicola. This result reflected the importance of different species besides mammals as potential reservoirs and responsible for maintaining leptospirosis in the environment.

Resumo: O Rio Grande do Sul possui uma grande diversidade de espécies de répteis distribuídos por todo o Estado. Devido às ações antrópicas, como a fragmentação de habitats, estes animais vêm sendo observados com frequência no meio urbano e periurbano. Isso facilita a disseminação de patógenos entre animais e seres humanos, sendo um risco à saúde única, visto que muitas doenças são consideradas zoonoses. A leptospirose está entre as zoonoses mais comuns do mundo e é causada pelas espécies patogênicas da bactéria

do gênero *Leptospira*. Ainda não se sabe o papel dos répteis no ciclo da doença, porém, estudos sorológicos demonstraram positividade para anticorpos contra *Leptospira* spp. em cágados e serpentes, o que pode indicar que estes animais atuam na manutenção do patógeno no ambiente. O objetivo deste estudo foi observar a presença de anticorpos anti-*Leptospira* em répteis oriundos de resgate e levados ao Núcleo de Reabilitação da Fauna Silvestre e Centro de Triagem de Animais Silvestres da Universidade Federal de Pelotas (NURFS-CETAS/UFPEL). As amostras foram coletadas de 55 animais (39 *Trachemys dorbignii*; 3 *Philodryas patagoniensis*; 3 *Caiman latirostris*; 3 *Salvator merianae*; 2 *Acanthochelys spixii*; 2 *Phrynosoma hilarii*; 2 *Hydromedusa tectifera*; 1 *Philodryas aestiva*), durante o período de agosto de 2022 a dezembro de 2023, e testadas para 12 sorovares de referência. Dois animais demonstraram positividade, um deles para o sorovar patogênico Pyrogenes e outro para o sorovar patogênico Canicola. Este resultado demonstra a importância de outras espécies, além dos mamíferos, como potenciais reservatórios e responsáveis pela manutenção da leptospirose no ambiente.

Matanzima, J. and Utete, B. (Eds.) (2024). *Living with Wildlife in Zimbabwe - Navigating Conflict and Co-existence*. Springer: Cham.

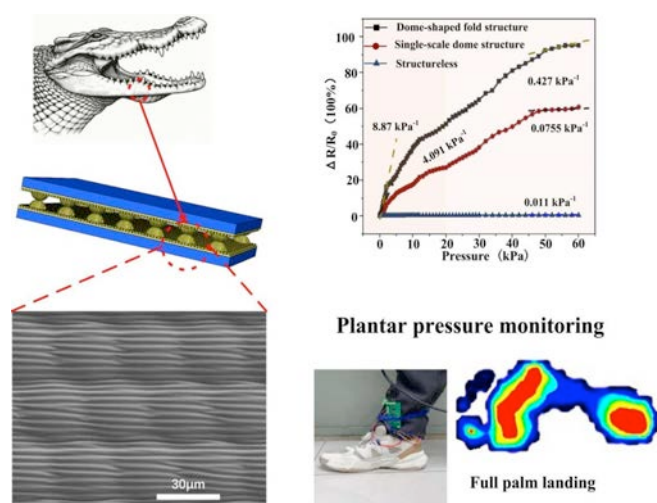
Utete, B. (2024). Human-Wildlife-Water Conflicts (HWWC) inside and outside of protected areas in Zimbabwe. Pp. 173-196 in *Living with Wildlife in Zimbabwe - Navigating Conflict and Co-existence*, ed. by J. Matanzima and B. Utete. Springer: Cham.

Abstract: Humans and wildlife share conservation landscapes and interaction is inevitable. Such interaction, mostly, results in negative outcomes for either parties through injury, harm, fatality, displacement, translocation, and restriction (confinement). Human wildlife conflict (HWC) has straightforward dynamics and is often more reported in Problem Animal Control (PAC) in terrestrial landscapes. However, HWC is complex and less often reported for aquatic systems inside and outside of protected areas in Zimbabwe. The fact that most of the protected areas are located in arid or semi-arid regions in the country implies that there is more competition among livestock, humans and wildlife for the scarce water resources. Such competition over water resources is termed human-wildlife-water conflict (HWWC in this Chapter) and has negative consequences on both wildlife biodiversity and livelihoods. The negative consequences of HWC in aquatic systems induces resentment towards the predators comprising mainly the Nile crocodile (*Crocodylus niloticus*), amphibious common hippopotamus (*Hippopotamus amphibious*) and the Nile monitor lizard (*Varanus niloticus*). In this chapter the focus is on the drivers of water conflicts, the risky livelihood activities that exposes humans and livestock to attacks from predators, and local perceptions on PAC in aquatic systems inside and outside of protected areas in Zimbabwe.

Liang, Y., Mi, X., Yang, S., Wang, J. and Zhang, C. (2024). High-performance flexible pressure sensors with bionic dome-shaped fold structures inspired by crocodile skin. *Sensors and Actuators A: Physical* 378 (<https://doi.org/10.1016/j.sna.2024.115827>).

Abstract: Flexible pressure sensors have drawn substantial community interest as a result of the advancement of contemporary technology. Inspired by the unique sensory organs of crocodiles, an ordered bionic dome-shaped fold structure array was prepared using a facile process in this paper, and electrical experiments confirmed the enhancement of the capabilities of piezoresistive flexible pressure sensors. The results revealed that this type of flexible pressure sensor presented a sensitivity of 8.87 kPa⁻¹, could withstand a maximum pressure of 60 kPa, a minimum detection pressure of 10 Pa, a response time of 70 ms, and maintained stable performance under 5000 repeated presses. In addition, the flexible pressure sensors based on dome-shaped fold structure arrays have been successfully applied for human signal detection and plantar

pressure monitoring system. The current research has significant implications for the manufacturing and practical applications of highly effective flexible pressure sensors.



Vyas, R. (2024). Banyan City becomes Makara City: My City, Motto and Marsh Crocodile. Reptile Rap #257, Zoo's Print 39(8): 5-10.

Nhan Nguyen, J.J. (2024). A reassessment of the Eocene crocodyloid *Asiatosuchus grangeri* Mook, 1940 and its implications on the phylogenetic relationships and evolution of Paleogene crocodiles. MSc thesis, University of Iowa, Iowa City, Iowa, USA.

Abstract: The genus *Asiatosuchus* has historically been used as a wastebasket taxon, referring to a basal crocodile from the Paleogene and has been attributed to species from across North America and Eurasia. These species represent some of the closest extinct relatives to all modern crocodiles, possessing a combination of ancestral and derived traits to the crocodile lineage. Many of these species are represented by only fragmentary remains and are poorly described in the literature, leading to a lack of resolution in the phylogenetic relationships of these species. This study sought to reassess the type species for this genus, *Asiatosuchus grangeri* Mook, 1940, which was recovered from the early to middle Eocene Arshanto Formation in the Erlian Basin of Inner Mongolia, China. All known fossil specimens were reexamined to construct a composite model of the species and used to create a comprehensive morphologic description. From this description, a maximum parsimony analysis was conducted to ascertain the nature of its evolutionary relationships with other basal crocodiles and to compare it to other species which have been previously referred to *Asiatosuchus*. *Asiatosuchus grangeri* largely resembles a modern crocodile, with a dorsoventrally compressed skull and triangular snout, but with a more lingual tooth occlusal pattern, flatter orbits, and longer dentary symphysis. Compared to previous analyses, *A. grangeri* was found to be somewhat more derived and less closely related to other species that have been previously referred to the genus. The phylogenetic trees generated from this study demonstrate a transition of traits from the ancestral crocodylid to the modern crocodile. The results of this analysis potentially point towards an Asian lineage of early crocodile which may have persisted from the Late Cretaceous up to the Eocene, with the Asian species *Asiatosuchus nanlingensis* Young, 1964 being returned in some trees as closely related to *A. grangeri*, though this remains uncertain due to *A. nanlingensis*'s lability in this study. Further studies are required among basal crocodylids to both resolve the remaining degree of uncertainty in their phylogenetic relationships and reclassify species that should no longer be diagnosed to *Asiatosuchus*, as well incorporate these findings with other crocodylian groups to assess larger scale evolutionary patterns.

Carey, M.E. (2024). Forever chemicals in modern alligators: Using CERCLA to force polluters to pay for PFAS contamination of Florida alligators. UCLA Journal of Environmental Law and Policy 42(1): 1-46.

Abstract: First, this paper will describe what forever chemicals are and the damage these compounds inflict. This paper will then explore what a CERCLA NRD assessment is: a tool to protect the public from chemicals like PFAS. The goals of NRD assessments can be tied back to the Public Trust: a sovereign holding natural resources in public trust for the citizenry. After briefly discussing pending federal regulatory action, which would list PFOA and PFOS as hazardous and thus pull them under CERCLA's jurisdiction, this paper will propose two potential solutions to the problems trustees face when asserting NRD claims. To illustrate these problems and their proposed solutions, this paper uses the Florida marine environment and one of the oldest and most treasured natural resources in the animal kingdom, the alligator, as a muse. The first solution the paper proposes is that Congress amend CERCLA to exempt public or municipal wastewater treatment facilities and waste management facilities from litigation related to NRD assessments. Additionally, this paper proposes that Congress amend CERCLA to broaden the potentially responsible parties to include manufacturers of PFAS chemicals, as they so often fall outside CERCLA's four statutorily responsible parties. Finally, this paper will show the NRD process will bolster the science around PFAS, proving causation and not just correlation, so that all potentially responsible parties can be held responsible.

Marzal, A., Flores-Saavedra, W., Magallanes, S., Muriel, J., Lezama-Briceño, J., García-Ayachi, L.A., Fong, E., Mora-Rubio, C., Mendoza, C., Saldaña, B., Díez-Fernández, A., Martín, J., Perea-Sicchar, C.M. and González-Blázquez, M. (2024). Host species and age-specific variation on *Hepatozoon* prevalence and its effect on body condition in two Neotropical crocodiles. Wildlife Biology 2024: e01302.

Abstract: Many populations of species belonging to the order Crocodylia are threatened due to illegal trafficking, indiscriminate hunting, and habitat loss and degradation affecting crocodylian health and parasitic load. Although several studies have revealed that crocodiles, caimans, and alligators are frequently infected by *Hepatozoon* spp., the results from studies exploring the costs of these apicomplexan parasites on the health of their reptilian hosts are still scarce and with inconclusive results. Here, we molecularly assessed the prevalence and genetic diversity of *Hepatozoon* spp. to explore their possible influence on body condition in captive individuals of two species of Neotropical crocodylians with conservation threats, the spectacled caiman *Caiman crocodilus* and the American crocodile *Crocodylus acutus*. Fourteen percent of spectacled caimans were infected by *H. caimani*, whereas no American crocodiles showed infection. The prevalence of *Hepatozoon* in spectacled alligators varied along age, where subadult individuals were the most frequently parasitized. Surprisingly, the body condition of infected individuals was significantly higher than body condition of uninfected spectacled caimans, which suggests greater negative effects of the infection in individuals of poor quality. Also, the body condition of subadult individuals was significantly higher than body condition of juveniles of both alligator species, likely reflecting differences in the occupancy of habitats with higher resource abundance, or variations in the nutritional values of the diet between these age classes. These outcomes provide valuable information on disease ecology for developing conservation strategies and the management conservation of wildlife populations of these species.

Umeki, Y., Hala, D. and Petersen, L.H. (2024). Optimization of an *in situ* liver perfusion method to evaluate hepatic function of juvenile American alligators (*Alligator mississippiensis*). Biology Open 13(8): bio060532.

Abstract: American alligators (*Alligator mississippiensis*) are a sentinel species whose health is representative of environmental quality. However, their susceptibility to various natural or anthropogenic stressors is yet to be comprehensively studied. Understanding hepatic function in such assessments is essential as the liver is the central organ in the metabolic physiology of an organism, and therefore influences its adaptive capability. In this study, a novel liver perfusion system was developed to study the hepatic physiology of juvenile alligators. First, a cannulation procedure was developed for an in situ liver perfusion preparation. Second, an optimal flow rate of 0.5 ml/min/g liver was determined based on the oxygen content in the effluent perfusate. Third, the efficacy of the liver preparation was tested by perfusing the liver with normoxic or hypoxic Tyrode's buffer while various biomarkers of hepatic function were monitored in the effluent perfusate. Our results showed that in the normoxic perfusion, the aspartate transferase (AST) and lactate/pyruvate ratio in the perfusate remained stable and within an acceptable physiological range for 6 h. In contrast, hypoxia exposure significantly increased the lactate/pyruvate ratio in the perfusate after 2 h, indicating an induction of anaerobic metabolism. These results suggest that the perfused liver remained viable during the perfusion period and exhibited the expected physiological response under hypoxia exposure. The liver perfusion system developed in this study provides an experimental framework with which to study the basic hepatic physiology of alligators and elucidate the effects of environmental or anthropogenic stressors on the metabolic physiology of this sentinel species.

Scott, A., Cramberg, M., DeLeeuw, H., Dille, M., Parker, S., Pick, E., Sopko, S., Swords, A., Taylor, E., Thompson, M. and Young, B.A. (2024). Infusing the alligator: Infusion studies in a low compliance system. *Neurology and Neuroscience* 5(2): 12.

Abstract: An infusion study is a neurological procedure in which a volume of fluid is added to the existing cerebrospinal fluid. The additional fluid volume increases the intracranial pressure; by monitoring how the system responds to this challenge, the clinician gains insight into the compliance of the dura and nervous tissue. Though commonly used clinically, the invasive nature of infusion studies means that they have rarely been applied in non-clinical studies, and appear to have only been used on mammalian subjects. Infusing a bolus of artificial cerebrospinal fluid into the cranial compartment of the American alligator (*Alligator mississippiensis*), produces pressure/volume curves with most of the attributes seen during infusion studies of humans or other mammals. Two consistent, unusual findings were noted: the compliance in the cranial compartment of *Alligator* is low (around 1.0) likely due to the small size of both the compartment and the dural sinuses; and the peak pressure drops off much faster than in a typical infusion study. A second round of bolus infusions was performed, these had a bidirectional design with infusions conducted at the midpoint of the spinal compartment as well as the cranial compartment. Similar results were obtained: the spinal compartment compliance was low (around 1.0), and the peak infusion pressures dropped off quickly with minimal propagation to the other compartment. The spinal dura of *Alligator* is ensheathed by a large venous sinus, which contributes to the low compliance of the spinal compartment. A final round of bidirectional infusions tested the influence of the spinal venous sinus; a bolus of Ringer's solution was injected into the sinus immediately before the infusion. As expected, the pressurization of the spinal venous sinus lowered the compliance of the system, raising peak infusion pressures; however, the pressures still showed rapid decay with little propagation to the other compartment. Herein it is proposed that the paradox of low compliance coupled with rapid pressure loss and minimal pressure propagation is present because the spinal dura of *A. mississippiensis* functions as a pressure modulated relief system for the cerebrospinal fluid.

Recharte, M., Lee, P., Vick, S-J. and Mark Bowler (2024). Using existing preferences to select flagships for tourism and conservation

- a 'Big five' for a megadiverse region? ESS Open Archive. August 28, 2024 (<https://doi.org/10.22541/au.172481796.67827097/v1>).

Abstract: Flagship species are used to promote conservation and tourism. Africa's famous 'Big Five', have become marketing flagships that fundraisers and tourism promoters emulate on other continents, choosing regional groups of species for marketing campaigns. Selections can be based on characteristics identified as appealing: colour, size, or behaviour, but this approach may overlook unique flagships or homogenise selections. Polling the public to reveal existing preferences for animals may identify suitable species more directly. We used questionnaires with tourists in the Peruvian Amazon to identify existing biases for species suitable for tourism and conservation marketing. Without a species list, preferences were expressed at inconsistent taxonomic levels. The response 'monkeys' (infraorder Simiiformes) was highest ranked, followed by 'jaguar' (*Panthera onca*), 'Amazon dolphin' (*Inia geoffrensis*), 'sloths' (suborder Folivora), 'caiman' (subfamily Caimaninae) and 'birds' (class Aves). When ranking species from a preselected shortlist, jaguar, Amazon dolphins, and sloths (represented by *Bradypus variegatus*) remained popular, while vote splitting within higher taxonomic levels, in particular monkeys, made room in the top rankings for green-winged macaw (*Ara chloropterus*) and anaconda (*Eunectes murinus*). When asked about their willingness to pay for excursions or donate to conservation, tourists were overwhelmingly more likely to quote larger figures to see or conserve jaguars than any other species, but results for other species were more homogenous. Important species for tourism in rainforest regions are often from diverse taxonomic groups; monkeys may be represented by 8-14 species at single sites in Amazonia, birds by several hundred species. A big five strategy obscures this diversity. Similarly, using physical characteristics as selection criteria underplays diversity and can overlook popular taxa. A strategy of polling the public to identify regional flagships more directly identifies salient species for marketing and is especially useful where budgets are limited, but diversity may trump the Big five approach in megadiverse areas.

Baker, C.J., Campbell, M.A., Udyawer, V., Kopf, R.K. and Campbell, H.A. (2024). The influence of crocodile density on the prevalence of human attacks. *People and Nature* (<https://doi.org/10.1002/pan3.10693>).

Abstract: Large predator attacks on humans often provoke calls for animal population reduction, assuming it will reduce such incidents. Whilst this seems logical, there is currently little evidence supporting a consistent link between large predator density and attacks on humans. Here, we assessed whether large predator density is linked to the frequency of attacks on humans using estuarine crocodile (*Crocodylus porosus*) data in the Northern Territory (NT), Australia. Over the past 50 years, the estuarine crocodile population in the NT has grown from a few thousand to over 100,000 non-hatchling individuals. Crocodile and human population densities have been closely monitored throughout this period, allowing the frequency of attacks on humans to be assessed over a wide range of densities for both populations. Our analysis showed an increase in the frequency of attacks on humans as the crocodile population recovered from very low levels in the 1970s. However, the attack rates stabilised around 2009, despite crocodile density and the human population continuing to increase. Based on the relationship between crocodile density and human-attack frequency, scenario modelling suggested that the crocodile population would need to be culled to a critically endangered level (eg 90% population reduction) to reduce attacks on humans from 2.16 to 1.16 attacks per year. We conclude that whilst crocodile density significantly influences crocodile attack rates at low crocodile population sizes, this relationship becomes weaker as the density increases. For estuarine crocodiles in the NT, a plateauing of attack risk occurred once crocodile density attained ~2 crocodiles per km of river, and we argue that this was because high crocodile densities instigated management (eg removal of bold animals, exclusion zones) and education initiatives by the government (eg. 'Be crocwise' campaign) that subsequently evoked a change in

huan behaviour around waterways and stabilised the attack rate.

Bona, P., Barrios, F., Ezcurra, M.D., Fernandez Blanco, M.V. and Mendes Cidade, G. (2024). New taxa of giant caimans from the southernmost hyperdiverse wetlands of the South American late Miocene. *Journal of Systematic Palaeontology* 22(1) (<https://doi.org/10.1080/14772019.2024.2375027>).

Abstract: Here we present a comparative anatomical study of large late Miocene alligatorids of Argentina (Ituzaingó Formation), in which we analyse their taxonomy, morphological disparity, and phylogenetic relationships. '*Caiman lutescens*' and *Caiman gasparinae* are two giant Miocene Argentinean caimanines that are assigned to the genus *Caiman*. '*Caiman lutescens*' was originally described based on the large size of several isolated cranial and postcranial elements. In this study we consider that the lectotype of '*C. lutescens*', an articulated left premaxilla and maxilla (MACN-Pv 5416), is morphologically indistinguishable from rostral morphotypes present in other jacarean caimanines, like *Caiman latirostris* and *Caiman wannlangstoni*, and therefore '*C. lutescens*' is here considered a *nomen dubium* while MACN-Pv 5416 is an indeterminate Jacarea. A partial skull table, MACN-Pv 13551, was originally and historically referred to '*C. lutescens*', and even wrongly considered its holotype, but it is here redescribed and reinterpreted as the holotype of a new genus and species. Additionally, after the comparative anatomical study of the holotype of *C. gasparinae* (MLP-Pv 73-IV-15-1), we conclude that it shows a distinctive combination of skull morphological features that allows it to be distinguished from other caimanines, including extant *Caiman* species. This situation and the results of the phylogenetic analyses lead us to erect a new genus for this species, which results in a new nomenclatorial combination. These new results support the idea that the alligatorid assemblages of the South American late Miocene wetlands were highly diverse at high latitudes (c. 30–35°S), as evidenced by the taxonomic diversity and morphological disparity present in the crocodylian assemblage of the Ituzaingó Formation in Paraná. The close relationship between the two new taxa + *Mourasuchus* spp. with *Purussaurus* spp. recovered in the present study reinstates the question of how to define the *Caiman* genus, as well as when and where it originated. <http://zoobank.org/urn:lsid:zoobank.org:pub:6096F826-7CCA-4795-B4CF-5AFF87D6EBCC>

D'Amore, D.C., Johnson-Ransom, E., Snively, E. and Hone, D.W.E. (2024). Prey size and ecological separation in spinosaurid theropods based on heterodonty and rostrum shape. *The Anatomical Record* (doi: 10.1002/ar.25563).

Abstract: Members of the dinosaur clade Spinosauridae had numerous traits attributed to feeding in or around water, and their feeding apparatus has often been considered analogous to modern crocodylians. Here we quantify the craniodental morphology of Spinosauridae and compare it to modern Crocodylia. We measured from spinosaurid and crocodylian skeletal material the area of alveoli as a proxy for tooth size to determine size-heterodonty. Geometric morphometrics were also conducted on tooth crowns and tooth bearing regions of the skull. Spinosaurids overall had relatively large alveoli, and both they, and crocodylians, had isolated regions of enlarged alveoli. Spinosaurines also had enlarged alveoli along the caudal dentary that baryonychines lacked, which instead had numerous additional caudal tooth positions. Size-heterodonty was positively allometric, and spinosaurids overlapped with generalist/macro-generalist crocodylians of similar sizes. Spinosaurid crown shape morphologies overlapped with certain slender-longirostrine crocodylians, yet lacked molariform distal crowns typical of most crocodylians. Spinosaurid rostra and mandibles were relatively deep with undulating margins correlating with local tooth sizes, which may indicate a developmental constraint. Spinosaurines had a particularly long concavity caudal to their rosette of anterior cranial teeth, with a corresponding bulbous rostral dentary. The spinosaurid

feeding apparatus was well suited for quickly striking and creating deep punctures, but not cutting flesh or durophagy. The jaws interlocked to secure prey and move it deeper into the mouth. The baryonychines probably did little oral processing, yet spinosaurines could have processed relatively large vertebrates. Overall, there is no indication that spinosaurids were restricted to fish or small aquatic prey.

Rodriguez-Cordero, A.L., Balaguera-Reina, S.A., Gross, B.A., Munn, M. and Densmore III, L.D. (2024). Assessing abundance-suitability models to prioritize conservation areas for the dwarf caimans in South America. *Ecology and Evolution* 14(9): e70235.

Abstract: Species-environment relationships have been extensively explored through species distribution models (SDM) and species abundance models (SAM), which have become key components to understand the spatial ecology and population dynamics directed at biodiversity conservation. Nonetheless, within the internal structure of species' ranges, habitat suitability and species abundance do not always show similar patterns, and using information derived from either SDM or SAM could be incomplete and mislead conservation efforts. We gauged support for the abundance-suitability relationship and used the combined information to prioritize the conservation of South American dwarf caimans (*Paleosuchus palpebrosus* and *P. trigonatus*). We used 7 environmental predictor sets (surface water, human impact, topography, precipitation, temperature, dynamic habitat indices, soil temperature), 2 regressions methods (Generalized Linear Models-GLM, Generalized Additive Models-GAM), and 4 parametric distributions (Binomial, Poisson, Negative binomial, Gamma) to develop distribution and abundance models. We used the best predictive models to define four categories (low, medium, high, very high) to plan species conservation. The best distribution and abundance models for both *Paleosuchus* species included a combination of all predictor sets, except for the best abundance model for *P. trigonatus* which incorporated only temperature, precipitation, surface water, human impact, and topography. We found non-consistent and low explanatory power of environmental suitability to predict abundance which aligns with previous studies relating SDM-SAM. We extracted the most relevant information from each optimal SDM and SAM and created a consensus model (2,790,583 km²) that we categorized as low (39.6%), medium (42.7%), high (14.9%), and very high (2.8%) conservation priorities. We identified 279,338 km² where conservation must be critically prioritized and only 29% of these areas are under protection. We concluded that optimal models from correlative methods can be used to provide a systematic prioritization scheme to promote conservation and as surrogates to generate insights for quantifying ecological patterns.

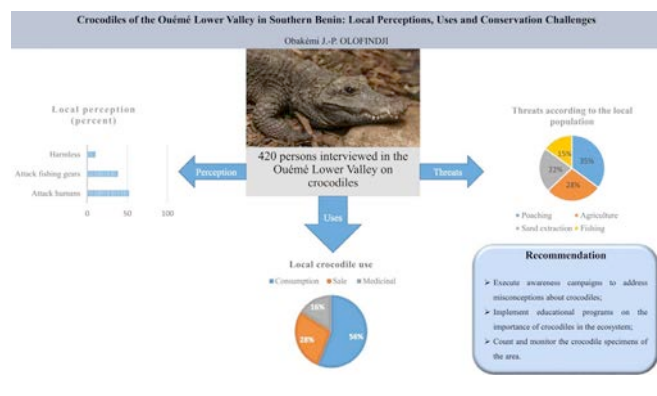
Crossley II, D.A., Crossley, J.L., Conner, J.L., Smith, B., Elsey, R., Nelson, D. and Wang, T. (2024). Temperature effects on blood gases in embryonic American alligators (*Alligator mississippiensis*). *Comparative Biochemistry & Physiology A Molecular and Integrative Physiology* (doi: 10.1016/j.cbpa.2024.111733).

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_2 , PCO_2 and glucose. However, blood pH suggests embryonic alligators lack an acute regulatory mechanism for adjusting blood pH.

Olofindji, O.J-P. (2024). Crocodiles of the Ouémé Lower Valley in southern Benin: Local perceptions, uses and conservation challenges. *Global Ecology and Conservation* (<https://doi.org/10.1016/j.gecco.2024.e03172>).

Abstract: The Ouémé Lower Valley, located in Southern Benin, is renowned for its rich biodiversity, which includes three species of crocodiles. Despite the presence of the crocodile species, the relation between these species and the local population is not well known. In this study, we aimed to examine local perceptions of crocodiles, document their uses, and identify conservation challenges. Over a period of 10 months, we surveyed the local population to understand their perceptions of crocodiles and the uses they make of these animals. Given the critical role of perceived threats in shaping conservation attitudes and behaviours, our objective also included analyzing perceived threats to crocodiles. From the 420 individuals interviewed, 90% have a negative perception of crocodiles, perceiving them as harmful. However, 10% of respondents, mainly from the 'Xwla' ethnic group, have a positive perception, perceiving crocodiles as harmless and beneficial. Local communities attribute various virtues to crocodile by-products, with crocodile teeth being the most cited, valued for their protective qualities. According to them, the decline in crocodile populations in the area is attributed primarily to poaching, agriculture, and sand extraction, as reported by 35%, 28%, and 22% of respondents, respectively. Educational initiatives aimed at raising awareness about the ecological significance of crocodiles should be implemented, particularly targeting ethnic groups with negative perceptions of crocodiles in the region. Future researches are also needed in order to study in deep the impacts of anthropic activities on the crocodile population in the area.



Mikia, M., Tsoumou, A., Dossou-Yovo, L.R., Olabi-Obath, D.B. and Mady-Goma, D.I. (2024). Morphometric characterization of the dwarf crocodile *Osteolaemus tetraspis* (Cope, 1861) (Crocodylia: Crocodylidae), sold on the markets of Brazzaville (Congo). *Journal of Animal & Plant Sciences* 61(1): 11127-11137.

Abstract: A study of the morphometric and anatomical characterization of the dwarf crocodile sold in the northern markets of Brazzaville (Ouenzé and Dragage) was conducted in the period from November to December 2020. Ten (10) specimens were purchased, measured and weighed in the laboratory. Growth parameters were assessed on ten (10) specimens and seven (7) eggs were also purchased, measured and weighed. The results show that the size of the specimens examined ranges from 83.5 to 126 cm, for an average of 102.59 ± 13.25 cm; with a weight ranging from 2 to 8.1 kg for an average of 4.18 ± 1.89 kg. The weight-to-length coefficient of the weight-length ratio is greater than 3, showing an increasing allometric growth. The length of purchased eggs varies between 62.04 and 67.39 mm, ie an average of 65.52 ± 1.94 mm.

The diameter varies between 36.29 and 39.93 mm; ie an average of 36.29 ± 1.47 mm. Their weight varies between 52.64 and 62.32 g, ie an average of 58.328 ± 3.48 g.

Sung, H., Tellez, M. and Reed, F.A. (2024). Out with the old, introgression with the new: Signals of ancient and recent admixture in hybridizing Mesoamerican crocodiles (*Crocodylus acutus* x *Crocodylus moreletii*). *ESS Open Archive* August 29, 2024 ([doi: 10.22541/au.172495233.38087730/v1](https://doi.org/10.22541/au.172495233.38087730/v1)).

Abstract: A central aim of conservation is to preserve existing biodiversity and understand the ecological and evolutionary processes that support it. Inter- and intra-specific hybridization in wildlife has been recognized as a common and naturally occurring phenomenon that facilitates species adaptation and evolution. However, hybridization still constitutes one of the most challenging problems for legal protection and species management due to its perceived biological risk, lack of regulatory oversight, and different case-by-case impacts. When considering rare or threatened hybridizing species with unequal legal protection, management strategies risk being inaccurate or unsuccessful unless contextualized with an informed understanding of the species' genetic and evolutionary backgrounds. We investigated hybridization dynamics and genetic diversity of American crocodiles (*Crocodylus acutus*) and Morelet's crocodiles (*Crocodylus moreletii*) from Belize to ascertain whether genetic exchange through admixture displayed signs of evolutionary significance. Using genomic reduced representation (3RAD) datasets from 242 wild crocodile samples, we found evidence of population structure among *C. acutus*, as well as ancient bidirectional gene flow that had occurred between *C. acutus* and *C. moreletii*. Notably, we also found evidence of high levels of recent admixture along the coastal *Crocodylus* populations in areas with extensive habitat modification due to human impact. These findings as well as a discovered disconnect between morphological and genetic species assignments used to identify populations have implications for conservation management practices and suggest a range of additional genetic investigations to understand the natural and anthropogenic role of hybridization in large long-lived tropical predators that span marine and terrestrial ecosystems.

Liu, Y., Che, S., Ai, L., Song, C., Zhang, Z., Zhou, Y., Yang, X. and Xian, C. (2024). Camouflage detection: Optimization-based computer vision for *Alligator sinensis* with low detectability in complex wild environments. *Ecological Informatics* (<https://doi.org/10.1016/j.ecoinf.2024.102802>).

Abstract: *Alligator sinensis* is an extremely rare species that possesses excellent camouflage, allowing it to fit perfectly into its natural environment. The use of camouflage makes detection difficult for both humans and automated systems, highlighting the importance of modern technologies for animal monitoring. To address this issue, we present YOLO v8-SIM, an innovative detection technique specifically developed to significantly enhance the identification precision. YOLO v8-SIM utilizes a sophisticated dual-layer attention mechanism, an optimized loss function called inner intersection-over-union (IoU), and a technique called slim-neck cross-layer hopping. The results of our study demonstrate that the model achieves an accuracy rate of 91%, a recall rate of 89.9%, and a mean average precision (mAP) of 92.3% and an IoU threshold of 0.5. In addition, the model operates at a frame rate of 72.21 frames per second (FPS) and excels at accurately recognizing objects that are partially visible or smaller in size. To further improve our initiatives, we suggest creating an open-source collection of data that showcases *A. sinensis* in its native environment while using camouflage techniques. These developments collectively enhance the ability to detect disguised animals, thereby promoting the monitoring and protection of biodiversity, and supporting ecosystem sustainability.

Milnes, M.R. and Moore, B.C. (2024). Hormones and reproductive cycles in crocodilians. Pp. 271–288 in *Hormones and Reproduction of Vertebrates, Volume 3 Reptiles*, ed. by D.O. Norris and K.H. Lop. Academic Press.

Baker, C.J., Class, B., Dwyer, R.G., Franklin, C.E., Campbell, H.A., Irwin, T.R. and Frère, C.H. (2024). Active crocodiles are less sociable. *Philosophical Transactions of the Royal Society of London B* 379(1912) (doi: 10.1098/rstb.2022.0528).

Abstract: How animals move and associate with conspecifics is rarely random, with a population's spatial structure forming the foundation on which the social behaviours of individuals form. Studies examining the spatial-social interface typically measure averaged behavioural differences between individuals; however, this neglects the inherent variation present within individuals and how it may impact the spatial-social interface. Here, we investigated differences in among-individual (co)variance in sociability, activity and site fidelity in a population of wild estuarine crocodiles, *Crocodylus porosus*, across a 10-year period. By monitoring 118 crocodiles using coded acoustic transmitters and an array of fixed underwater receivers, we discovered that not only did individual crocodiles repeatably differ (among-individual variation) in each behaviour measured but also in how consistently they expressed these behaviours through time (within-individual variation). As expected, crocodile activity and sociability formed a behavioural syndrome, with more active individuals being less sociable. Interestingly, we also found that individuals that were either more sociable or displayed greater site fidelity were also more specialized (lower within-individual variation) in these behaviours. Together, our results provide important empirical evidence for the interplay between spatial, temporal and social individual-level behavioural variation and how these contribute to forming behavioural niches. This article is part of the theme issue 'The spatial-social interface: a theoretical and empirical integration'.

Chilambe, B. (2024). Mapping of Human Wildlife Conflict Hotspots in Silwana Complex of Western Province in Zambia. MSc thesis, The University of Zambia, Lusaka, Zambia.

Abstract: This dissertation is about a study conducted on mapping HWC hotspots in Silwana Complex of Western Province in Zambia. Spatially identifying HWC (hotspots) and possible mitigation measures is necessary to inform HWC management in order to facilitate a nonviolent coexistence of humans and wildlife. This study used Earth Observation techniques, Geographic Information Systems and spatial modelling to identify areas at risk of HWC and possible mitigation measures to address the conflict, based on the Silwana Complex (SC) as a case study area. The study achieved three (3) specific objectives: it analysed forms of HWC; modelled HWC hotspots and established possible HWC mitigation measures in the case study area. The study achieved its objectives through a total of 200 HWC incident records covering 2020 to 2021 acquired from the Department of National Parks and Wildlife (DNPW). To supplement this dataset, a semi-structured questionnaire was administered to 100 respondents. The study modelled HWC occurrences together with environmental predictor variables extracted from the land cover map. The land cover map was classified from Sentinel 2 Level 1C satellite images using the Supported Vector Machine (SVM) algorithm in ArcGIS Pro (Version 2.4.1). Maximum Entropy (MaxEnt) software (Version 3.4.1) was used to model HWCs. The outputs were analyzed and mapped using ArcGIS Pro (Version 2.4.1). Further, the study found that, HWC is caused by the following species of wildlife in their order of magnitude; African elephants (*Loxodonta africana*) at 47%, Common Hippopotamus (*Hippopotamus amphibius*) at 24%, Nile crocodile (*Crocodylus niloticus*) at 21%, Blue wildebeest (*Connochaetes taurinus*), African buffalo (*Syncerus caffer*) and Spotted Hyena (*Crocuta crocuta*) at 2% each, Lions (*Panthera leo*) at 1% and Common duiker (*Sylvicapra grimmia*) at 1%. Further,

the study analyzed seasonal patterns of HWC and found that HWC occurred throughout the year with peaks in March and October. Further, the study found that a total of 550 km² or 55,000 hectares of SC (5% of its area) was at risk of HWC. The results showed that of the total HWC hotspot areas, 60% were in the GMA, 22% were in the Open area, and 18% were in the National Park. The study also established that community members practiced exclusionary and deterrent methods to mitigate HWC. The practice of these methods show that community members had knowledge of how to mitigate HWC. The study concluded that Lower West Zambezi GMA experienced more HWC than Sioma Ngwezi National Park. Further, human communities in the GMA are the most affected by HWC than those in the National Park. The study recommended that, DNPW and its conservation partners should consider promoting community-based HWC management, conservation education, livelihood diversification, and prioritize integrated land use planning in addressing HWC in both the National Park and GMA. In addition, future studies on this topic could largely replicating this model in other landscapes in Zambia. Further research is needed focused on quantifying the impacts (Physiological, Social and Economic) of HWC on local human communities.

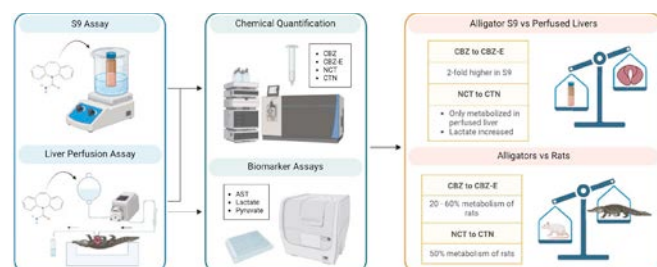
Velez, K. (2024). New Paleontological Records Provide Insights Into the Early Evolution and Biogeography of Gavialoids. PhD thesis, University of Michigan, Ann Arbor, Michigan, USA.

Abstract: Today, crocodylians are separated into three groups, Alligatoridae (*Alligator*, *Caiman*, *Melanosuchus*, *Paleosuchus*), Crocodylidae (*Crocodylus*, *Mecistops*, *Osteolaemus*), and Gavialidae (*Gavialis* and *Tomistoma*). The latter group, Gavialidae, is represented by one species that is restricted to the fluvial habitats of northern India and Nepal. However, the gavialid fossil record shows that the group was more diverse and geographically widespread, with specimens occurring on most continents. In this dissertation, I explore the paleontological record of gavialids using new fossil material and test historical biogeographical hypotheses. In the first part of this dissertation, I explore the evolutionary relationships of three putative oldest gavialoid groups in a phylogenetic context, all of which are Late Cretaceous in age. These putative early gavialids include *Dolichochoampsia minima* from South America, *Ocepesuchus eoafricanus* from Africa, and the 'thoracosaurus' from North America and Europe. Phylogenetic analyses show that *Ocepesuchus* is placed within Alligatoridae, 'thoracosaurus' as basal eusuchians, and *Dolichochoampsia* is nested within Gavialidae. The placement of *Dolichochoampsia* within Gavialidae suggests a possible South American origin for the clade that can be traced back to the Late Cretaceous. In the second part of this dissertation, I describe a new fossil gavialid from the Eocene (42 Ma) of Pakistan. The material is represented by cranial, mandibular, and some postcranial (scapula, vertebrae) elements. This new specimen extends the temporal range (42–41 Ma) of gavialids in Indo-Pakistan, indicating that the group possibly arrived in this region before closure of the Tethys Sea in the Miocene. The results of the morphological analyses demonstrate that the new specimen has strong affinities to Gryposuchinae, a gavialid lineage from the Miocene-Pliocene of South America, suggesting a possible origin for that clade in Asia. In the third part, I finally integrate the new paleontological record to reconstruct the historical biogeography of Gavialidae under a model that incorporates geographic and phylogenetic data. I then test the proposed biogeographic hypothesis of dispersals from Africa, Asia, and Europe to the Americas during the Paleocene-Oligocene against a model that does not include such dispersals (ie, vicariance). The results of this study show strong support for a model that includes the dispersals from Africa, Asia, and Europe to the Americas. Moreover, the best-fitting model shows multiple dispersal events: from Asia to the Americas during the Eocene; from Africa to the Caribbean during the Eocene; and from the Caribbean to South America in the Oligocene. This study highlights the importance of incorporating fossils in biogeographic models to understand the complex history of groups that are represented today by a few taxa. This dissertation offers valuable evidence for the early history, divergence time,

and paleobiogeography of gavialids, and demonstrates the use of Gavialidae as a case study to understand complex evolutionary and biogeographic hypotheses when using the fossil record.

Umeki, Y., Hala, D. and Petersen, L.H. (2024). Biotransformation of carbamazepine and nicotine in juvenile American alligator (*Alligator mississippiensis*) *in vitro* hepatic S9 vs. *in situ* perfused liver. Comparative Biochemistry and Physiology Part C: Toxicology & Pharmacology (<https://doi.org/10.1016/j.cbpc.2024.110015>).

Abstract: American alligators (*Alligator mississippiensis*) are apex predators and sentinel species in the coastal wetland ecosystem along the Gulf of Mexico. There is concern for alligator exposure and susceptibility to chemical contaminants due to their high trophic level and lower metabolic capability. At present, their hepatic biotransformation capacity to metabolize or detoxify contaminants has not been comprehensively determined. In this study, the hepatic biotransformation capability of juvenile American alligators to metabolize two commonly found environmental pharmaceuticals: carbamazepine (CBZ) or nicotine (NCT) was evaluated. The formation of their respective primary metabolites, ie, carbamazepine-10,11-epoxide (CBZ-E) and cotinine (CTN), was evaluated at 10 μ M (within the human therapeutic range). The *in vitro* S9 and a novel *in situ* liver perfusion assays were used to characterize and compare metabolic ability in isolated hepatic enzymes vs. whole organ (liver). For CBZ, the perfused livers exhibited only 30 % of intrinsic formation clearance (CL_f , *int*) relative to the S9 assay. The metabolism of NCT was not detectable in the S9 assay and was only observed in the perfused liver assay. Compared to the corresponding rat models (S9 or perfused livers), alligators' CL_f , *int* was 20-60% for CBZ and 50% for NCT of rats. Additionally, NCT exposure increased lactate levels in perfused livers indicating metabolic stress. This study provides insight into the hepatic capability of alligators to metabolize CBZ and NCT using an established *in vitro* (S9) system and a newly developed *in situ* liver perfusion system.



Lordi, N.A. (2024). Embryo Size Classification at Egg Collection and its Relationship to Hatch Success and Umbilical Scarring in Florida Alligators (*Alligator mississippiensis*). MSc thesis, The Ohio State University, Columbus, Ohio, USA.

Abstract: The alligator industry is a multi-million dollar enterprise with farms located across most of the southeastern United States. The main source of revenue comes from harvesting hides. The presence of umbilical scars decreases the value of hides and has been identified as a significant issue in the industry. Umbilical scarring or defects are thought to be caused by incomplete absorption of the yolk sac and/or incomplete healing of the navel. It's currently unknown how factors related to incubation affect the incidence of umbilical scarring. Prior trials at our institution have examined how substrate type, oxygen supplementation, and temperature and humidity regimes may contribute to umbilical scarring and hatch success. Anecdotally, smaller embryos from previous trials appeared to have a higher chance of developing umbilical scar abnormalities along with a lower hatch rate. Our objectives included: (1) developing a non-lethal staging scheme to broadly classify the stage of embryo development during field collection of eggs using commonly identified embryonic features and (2) examining the hatch success and incidence of umbilical scarring in American

alligator (*Alligator mississippiensis*) in comparison to the embryo size classification at early candling. These objectives enabled us to pose the hypothesis that a lower hatch success, in addition to abnormal umbilical scarring, would be more common in embryos that are at an earlier stage of development at time of collection due to transport and handling stress. A total of 362 eggs from 12 clutches and two locations were incubated at a temperature of 32.1°C with a relative humidity of 85% or higher. Each egg was candled at least once to assign a developmental size classification (undetermined, small, small-medium, medium, medium-large, large) and record any key anatomic features or measurements. Post-hatch data included hatch success, umbilical assessment, length, and weight. The overall hatch success was 62%, while the hatch success for farm and wild sourced eggs were 47% and 80%, respectively. Although hatch success appeared to increase with increasing embryo size classification, a strong significant difference was observed only between small and large embryos ($q=0.03$). Of the 209 hatchlings that survived to umbilical scar assessment on day 98 following the eggs arrival at our institution, only 9 (4%) had an umbilical defect. A significant relationship between embryo size, length, weight, and umbilical scarring was not identified. A non-lethal embryo classification scheme was developed based on readily measurable or observed characteristics such as body length, limb morphology, tail flexion, and body pigmentation. Our findings highlight the potential for improved hatch success by allowing embryos to develop more prior to collection. Furthermore, the non-lethal staging scheme also provides farms with the ability to classify embryo size by selecting eggs based on embryologic development with relative ease in the field.

Burke, P.M.J., Boerman, A.A., Perrichon, G., Martin, J.E., Smith, T., Vellekoop, J. and Mannion, P.D. (2024). Endocranial anatomy and phylogenetic position of the crocodylian *Eosuchus lerichei* from the late Paleocene of northwestern Europe and potential adaptations for transoceanic dispersal in gavialoids. The Anatomical Record (<https://doi.org/10.1002/ar.25569>).

Abstract: *Eosuchus lerichei* is a gavialoid crocodylian from late Paleocene marine deposits of northwestern Europe, known from a skull and lower jaws, as well as postcrania. Its sister taxon relationship with the approximately contemporaneous species *Eosuchus minor* from the east coast of the USA has been explained through transoceanic dispersal, indicating a capability for salt excretion that is absent in extant gavialoids. However, there is currently no anatomical evidence to support marine adaptation in extinct gavialoids. Furthermore, the placement of *Eosuchus* within Gavialoidea is labile, with some analyses supporting affinities with the Late Cretaceous to early Paleogene "thoracosaur." Here we present novel data on the internal and external anatomy of the skull of *E. lerichei* that enables a revised diagnosis, with 6 autapomorphies identified for the genus and 10 features that enable differentiation of the species from *Eosuchus minor*. Our phylogenetic analyses recover *Eosuchus* as an early diverging gavialid gavialoid that is not part of the "thoracosaur" group. In addition to thickened semi-circular canal walls of the endosseous labyrinth and paratympanic sinus reduction, we identify potential osteological correlates for salt glands in the internal surface of the prefrontal and lacrimal bones of *E. lerichei*. These salt glands potentially provide anatomical evidence for the capability of transoceanic dispersal within *Eosuchus*, and we also identify them in the Late Cretaceous "thoracosaur" *Portugalosuchus*. Given that the earliest diverging and stratigraphically oldest gavialoids either have evidence for a nasal salt gland and/or have been recovered from marine deposits, this suggests the capacity for salt excretion might be ancestral for Gavialoidea. Mapping osteological and geological evidence for marine adaptation onto a phylogeny indicates that there was probably more than one independent loss/reduction in the capacity for salt excretion in gavialoids.

Delfino, M. and Villa, A. (2024). An overview of the skeleton of

reptiles. Pp. 39-56 in Volume 1 General Biology, Archosauria, Chelonina, ed. by U. Joger. De Gruyter: Berlin.

Gregorovicova, M. (2024). Cardiovascular system in reptiles. Pp. 57-74 in Volume 1 General Biology, Archosauria, Chelonina, ed. by U. Joger. De Gruyter: Berlin.

Crossley, J.L., Elsey, R., Crossley, D.A., Wang, T. and Hicks, J.W. (2024). There is no limitation for CO₂ excretion across the lung in exercising American alligators (*Alligator mississippiensis*). Journal of Experimental Biology (<https://doi.org/10.1242/jeb.248139>).

Abstract: Vertebrates utilize various respiratory organs like gills, lungs, and skin in combination with diverse cardiovascular structures, including single, three, and four-chambered hearts, to enable oxygen delivery and carbon dioxide removal. They also exhibit differences in aerobic and anaerobic metabolism during exertion, but the cardiorespiratory gas transport of all vertebrates follow is a similar a four-step process governed by Fick's Principle and Fick's Law of Diffusion over the entire range of metabolic rates. Hillman *et al.* (2013) suggested that previous exercise studies have focused too narrowly on mammals and proposed that the cardiorespiratory system's excess capacity serves an evolutionary role in enhancing CO₂ excretion in non-mammalian vertebrates. In contrast, an analysis by Hicks and Wang (2021) concluded that vertebrates maintain effective gas exchange even at peak activity, finding no evidence of arterial hypercapnia at maximal oxygen consumption and thus challenging the proposal of significant limitations to pulmonary or branchial CO₂ efflux. In the present study, we investigate the limits for CO₂ exchange in exercising American alligators (*Alligator mississippiensis*) and provide evidence that the cardiorespiratory system is adequately built to sustain CO₂ excretion during strenuous exercise and maintain arterial PCO₂, with no evidence of diffusion limitation for pulmonary CO₂ excretion.

Thorpe, J.H. (2024). Leviathans and Lightning Wielders. In: The Otter and the Fairy Shrimp. Springer: Cham.

Abstract: The principal focus of this chapter is on the nature of unusually large tropical and temperate zone freshwater animals, including hippos, crocodiles and alligators, snakes, turtles, salamanders, frogs, big fishes, and giant crayfishes. Also included is the capacity of some mostly tropical fishes (but also the platypus) to generate electricity for hunting, defense, and communication.

D'Cruze, N., Elwin, A., Perez-Peña, P.E., Vieto, R., Asfaw, A.E. and Harrington, L.A. (2024). Wildlife trade at Belén and Modelo market, Peru: defining a baseline for conservation monitoring. Frontiers in Conservation Science 5 (doi: 10.3389/fcsc.2024.1464332).

Abstract: Domestic wildlife markets have important nutritional, medicinal, cultural, and financial significance for local communities, but the scale and diversity of wildlife trade that passes through them is also associated with negative impacts on biodiversity, poor animal welfare, and potential human health risk. To design, and monitor the effectiveness of, interventions to ameliorate such impacts, an understanding of the species sold at the markets and their purpose is required, together with a robust (and potentially flexible) baseline. Here we focus on Belén (the largest open wildlife market in the Peruvian Amazon) and Modelo market, in Iquitos, Peru. To obtain a broad overview of the nature of these markets, and their potential impacts on native wildlife, we surveyed wildlife products for sale approximately weekly over a year, using two different survey methods (open and discreet). Both markets sold predominantly wild meat, and some pets; at Belén market >30% observations were of decorative, spiritual, or medicinal products. At least 71 unique species (including mammals, reptiles, birds, and invertebrates) were observed in total. 27.7% of species were

threatened or Near Threatened globally or nationally but there was no evidence that discreet surveys increased their detection. To provide a baseline to support future conservation monitoring, we present data on product availability, volume (observed per survey), and price, for the eight most frequently observed species 'groups' (lowland paca, peccaries, caiman, river turtles, boas, yellow footed tortoise, parrots, and brocket deer). Our aim was to quantify several different market metrics to maximize future utility of the dataset. To provide a complete understanding of the range of species involved, we also provide a description of all threatened species recorded at the markets, the products sold, and their uses, including those that were only observed occasionally. Beyond providing a comparative dataset, we suggest that simulations using these data could be used to optimize future monitoring efforts. Finally, our observations of correlations of per survey trade volumes of some species with daily river water levels in Iquitos (positive for lowland paca, caiman, yellow-footed tortoise and negative for parrots, river turtle eggs) may inform optimal time of year for species-specific surveys.

González-Solórzano, M., López-Luna, M.A., Hernández-Salazar, L.T., Bello-Sánchez, E.A. and Morales-Mávil, J.E. (2024). Variation in the diet of hatchling Morelet's crocodile (*Crocodylus moreletii*) in the wild. Animals 14: 2610.

Abstract: The relationship between diet and behavior is essential to understanding an animal's strategies to obtain food, considering ontogenetic changes. In reptiles, there is a relationship between the length of the individual and the size of the prey it consumes. Studies have focused on the ontogenetic changes in reptile diets from hatchling to adult, but only a few studies have focused on the transition from hatchling to juvenile. We aimed to describe and analyze the composition, variation, diversity, and overlap in the diet of hatchling Morelet's crocodiles (*Crocodylus moreletii*) for three size intervals during the hatchling-juvenile transition. We captured 31 hatchling Morelet's crocodiles in an urbanized lagoon in Tabasco. We performed stomach-flushing to determine the diet. Additionally, we estimated the volume, frequency of occurrence, and relative importance of diet items and analyzed the relationship between prey type and the total length of the individuals. The diversity of the hatchling prey suggests a generalist diet. We observed two items not previously described in the diet of hatchling crocodiles. In addition, we found differences in diet between the initial and final size intervals, as increases in the length of prey appeared that they did not consume when they were hatchlings. Our results contribute new information to the dietary changes that occur during the hatchling-juvenile transition.

Wang, Y., Liu, R., Hu, R., Chen, H., Li, Z., Yin, X. and Liu, Z. (2024). Histology and immunohistochemical analyses in the brain of juvenile Chinese alligator (*Alligator sinensis*). International Journal of Morphology 42(5): 1181-1188.

Abstract: In current study, we used Nissl staining to examine the histological structure of the juvenile Chinese alligator brain, and immunohistochemistry (IHC) staining to detail the serotonin (5-hydroxytryptamine, 5-HT) localization and morphology of neurons belonging to the serotonergic system. Nissl staining revealed that the Chinese alligator brain was divided into four regions (telencephalon, diencephalon, brainstem, and cerebellum) and a connected ventricular system (containing the pair of lateral ventricles, third ventricle, fourth ventricle and the aqueduct). According to the IHC results, 5-HT immunoreactive (5-HT-IR) neurons were primarily observed in the cerebral cortex, the hypothalamic paraventricular nucleus (PH), tectum and tegmentum of the optic lobes, the medial longitudinal fasciculus (Flm) of medulla oblongata and the cerebellar cortex. 5-HT-IR fibers were mostly located lateral to the hypothalamic paraventricular nucleus (PH), in the medial vestibular nucleus (MVe) of the medulla oblongata, and in the choroid plexus (CP) of the lateral ventricles. Additionally, our findings paralleled those results of other reptiles; nevertheless, some

distinctions in terms of both histological architecture and function were identified. The layering of the cerebral cortex and tectum, as well as the arrangement of Purkinje cells, differed between reptile brains. The distribution of 5-HT-IR neurons varied in the layer of cerebral and cerebellar cortex when compared to other reptiles. Within the diencephalon, 5-HT-IR neurons formed distinct nuclei in the hypothalamic paraventricular nucleus (PH), but few in the infundibular recess.

Muscioni, M., Chiarenza, A.A., Fernandez, D.B.H., Dreossi, D., Bacchia, F. and Fanti, F. (2024). Cranial anatomy of *Acynodon adriaticus* and extreme durophagous adaptations in Eusuchia (Reptilia: Crocodylomorpha). The Anatomical Record (doi: 10.1002/ar.25574).

Abstract: *Acynodon adriaticus*, a small eusuchian from the Late Cretaceous of Italy, is known for its well-preserved cranial and postcranial material. Despite its excellent preservation, many details remain hidden due to the physical overlap between the elements and matrix obliteration. We used Micro-CT scans to reveal previously overlooked anatomical features and describe in detail the cranial and dental anatomy of this taxon, shedding new light on its palaeoecology. The holotypic specimen, SC 57248, represents a mature individual exhibiting signs of hyperossification, developed ornamentation, and various pathologies, including jaw arthritis and a possible dental anomaly. *Acynodon adriaticus* exhibits significant durophagous adaptations, including a robust, brevisrostrine skull optimized for powerful biting and stress-load capacity. Its specialized dentition, lacking caniniform teeth, features anterior chisel-like teeth and hypertrophic posterior molariforms with thick enamel, indicative of a diet specializing in hard-shelled prey. The dentition pattern, accelerated molariform replacement rate, and reduced orbit size suggest adaptations for durophagous foraging in turbid, densely vegetated aquatic environments. The paleoecological context during the Late Cretaceous, characterized by increased freshwater habitats and high invertebrate diversity, likely facilitated the evolution of such specialized traits in *A. adriaticus*. This small crocodylomorph likely foraged slowly in shallow, benthic environments, using its powerful bite to process mollusks and large arthropods. The study of *A. adriaticus*, along with comparisons with other crocodylomorphs and ecomorphologically similar taxa like *Iharkutosuchus makadii* and *Gnatusuchus pebasensis*, provides a valuable morphofunctional model for understanding the evolutionary pathways of extinct crocodylians to durophagy.

King, G.E. (2024). Predation on hominins. Pp. 101-123 in *Baboon Perspectives on Early Human Ancestors*. Springer: Cham

Abstract: Early hominins lived among numerous and diverse predators, including carnivorans (mammals of the order Carnivora), raptors, crocodiles, and snakes. Baboon analogies, combined with the fossil record, indicate which predators were the most dangerous to hominins. Raptors were probably dangerous only to young hominins and might be repelled by adult aggression. Crocodiles were a danger to all and avoidance was the only defense. Predation by snakes may have been rare. Carnivorans, especially leopards and similar felids, were probably the greatest danger. They could ambush hominins in woodlands and from clumps of vegetation scattered across savannas. Baboon analogies show that hominins could have responded with avoidance through tactical movement and by association with species that intimidated predators or warned of their approach. When baboons flee from attack, they take refuge in trees or on cliff faces; early hominins, having retained some ancestral climbing ability, probably did the same. Baboons also threaten and fight carnivorans; hominins might also have done so, perhaps (as suggested by chimpanzee evidence) aided by simple weapons from a very early date. A key factor was and is the body mass of predators and prey. Danger from carnivorans is a primary factor causing baboons to sleep in trees or on cliff faces and early hominins probably did the same.

Thangsunan, P., Thangsunan, P., Uchuwittayakul, A., Suree, N. and Jakmunee, J. (2024). Colorimetric loop-mediated isothermal amplification (LAMP) for identification of crocodile meat in raw meat and commercial processed meat products. International Journal of Food Science + Technology 59(10): 7453-7463.

Abstract: Deliberate and accidental adulteration or substitution of crocodile meat with other meats is possibly seen in meat products, which could be challenging to identify. This research aims to develop a new loop-mediated isothermal amplification for accurately identifying crocodile meat in raw meat and processed food samples. Conditions for LAMP were initially optimised. The LAMP was proven for its high specificity to only crocodile DNA. The LAMP revealed a detection limit of 1 pg/μL crocodile DNA and 0.01% (w/w) crocodile meat in meat admixtures. From forty-seven commercial processed meat samples, the LAMP detected crocodile content in ten products with the declaration of crocodile on their labels. Without the requirement of DNA purification, the direct LAMP showed its ability to detect crocodile content in both fresh meat and processed meat samples. This LAMP could become a promising alternative to support the food industry, especially for on-site services and limited-resource laboratories.

Sazmand, A., Miadfar, M.P., Deak, G., Babaei, M., Mendoza-Roldan, J.A. and Otranto, D. (2024). Parasites of reptiles in Iran (1922-2023): A literature review. International Journal for Parasitology: Parasites and Wildlife 25 (https://doi.org/10.1016/j.ijppaw.2024.100992).

Abstract: Reptiles are among the most diverse groups of animals, inhabiting nearly all continents and environments. Understanding their parasite biodiversity has garnered significant interest, particularly from a One Health perspective. Although the highly diverse reptile fauna of Iran, comprising 272 species, ie 89 snakes (Serpentes), 171 lizards (Sauria), 8 turtles, 2 tortoises (Testudines), 1 crocodile (Crocodylia), and 1 worm-lizard (Amphisbaenia), there is a shortage of information about parasites. The present review is a compilation of 62 studies published from 1922 to August 2024. We present information on 56 species of reptiles from five groups (amphisbaenians, crocodiles, testudines, snakes, and lizards) and 98 parasitic taxa belonging to different protozoa and metazoa i.e. nematodes, cestodes, trematodes, acanthocephala, leeches, ticks, mites, and myiasis-producing flies. Although 63 taxa were diagnosed at the species level, 35 parasite taxa were only reported at the genus or family levels. Reviewing the literature, we found a paucity of information about endemic reptiles several of which are vulnerable species. Considering that some of the detected parasites eg *Cryptosporidium* and amoebae have serious clinical and/or public health threats molecular diagnostic techniques are needed for precise identification and understanding of the epidemiology and the potential zoonotic implications associated with parasites of reptiles. There is also a need to understand the exact distribution and host-parasite associations in different reptilian species present in Iran including the role of the reptiles as intermediate and reservoir hosts.

Yeong, W.Y., Martelli, P., Chung, T.Y., Tsui, H.C., Gerussi, T. and Kot, B.C. (2024). Ultrasonographic technique and appearance of the coelomic organs in crocodilians. Frontiers in Marine Science 11 (doi: 10.3389/fmars.2024.1423721).

Abstract: Crocodilians have significant ecological, conservational, and economic roles. They are also commonly raised for commercial purposes and kept as zoological specimens. Although ultrasonography has been used in zoological contexts for health assessments of crocodilians, published studies on a detailed ultrasonography protocol and ultrasonographic anatomy are lacking. This study aimed to establish a standardized ultrasonography protocol and pictorial reference of the ultrasonographic appearances of the coelomic organs of crocodilians. A total of 7 crocodilians comprising 4 different species were included in this study. The crocodilians were manually restrained and underwent a non-

contrasted and contrasted computed tomography (CT) scan, followed by an ultrasonography (USG) examination. Ultrasound fusion imaging technique was utilized to enable greater confidence in establishing a clear organ localization and correlation between modalities by visualizing the same anatomy from the same view angle. The heart, caudal vena cava, liver, fat body (steatotheca), spleen, stomach, duodenal loops, pancreas, kidneys, testes, ovaries and cloaca were visualized in all species. Longitudinal and transverse images of the coelomic structures were acquired when possible. The ultrasonographic characteristics including transducer positioning, acoustic window and approach, shape, size, marginations, and echo pattern were documented. The findings of this study provided a useful ultrasonographic anatomical reference of the coelomic organs in crocodilians, which could provide invaluable insights into the practicality and adequacy of ultrasonography in evaluating the coelomic structures of crocodilians as part of health assessment and disease diagnosis.

Smith, P., Maciel, J., Redin Hurtado, M., Galeano, S., Stepan, N., Brouard, J.-P., Ríos, S.D., Ferreira Riveros, M., Smith, R.L., Owen, M., Nicolay, H., Derna, R., Vera Burró, A., Lahaye, T. and Cacciali, P. (2024). Twenty-eight new and significant departmental reptile records for Paraguay. *Acta Zoológica Lilloana* 68(2): 347-385.

Abstract: Twenty-eight new distribution records are reported for twenty-seven species of Paraguayan reptiles. Eleven of these species are considered threatened at the national level (6 EN, 3 VU, 2 DD). Twenty-two new departmental records are documented: *Phrynops hilarii* (Chelidae) in Misiones department; *Homonota marthae*, *Phyllopezus przewalskii* (Phyllodactylidae), *Philodryas baroni* and *P. psammophidea* (Colubridae) in Presidente Hayes department; *Teius oculatus* (Teiidae), *Cercosaura schreibersii* (Gymnophthalmidae), *Ophiodes intermedius* (Diploglossidae), *Amphisbaena mertensii* (Amphisbaenidae), *Boiruna maculata* and *Philodryas aestiva* (Colubridae) in Caazapá department; *Amphisbaena alba* (Amphisbaenidae) in Caaguazú and Cordillera departments; *Bothrops jararaca* (Viperidae), *Eunectes notaeus* (Boidae), *Helicops leopardinus* and *Hydrodynastes gigas* (Colubridae) in Guairá department; *Apostolepis dimidiata*, *Atractus paraguayensis* and *Mussurana bicolor* (Colubridae) in Itapúa department; and *Epicrates crassus* (Boidae) and *Phalotris nigirilatus* (Colubridae) in Concepción department. Significant range extensions of threatened or poorly-known species are also documented: The known distribution of the Endangered *Salvator duseni* (Teiidae) is extended 128.5 km to the east within Canindeyú department; that of the Vulnerable *Boa occidentalis* is extended 109.2 km to the southwest within Boquerón department; that of the Vulnerable *Epicrates alvarezii* (Boidae) is extended 136.6 km to the west within Boquerón department and 172.4 km to the northeast into Alto Paraguay department; that of *Caiman yacare* (Alligatoridae) is extended 132 km west within Boquerón department to the northern reaches of the Pilcomayo River. We also document an additional specimen of the rare *Philodryas agassizii* (Colubridae) and confirmation of the occurrence of the disputed form *Phalotris "punctatus"* in Paraguay.

Resumen: Se reportan veintiocho nuevos registros de distribución para veintisiete especies de reptiles de Paraguay. Diez de estas especies están consideradas amenazadas a nivel nacional (6EN, 2VU, 2DD). Se documentan diecinueve nuevos registros departamentales: *Phrynops hilarii* (Chelidae) en el departamento de Misiones; *Homonota marthae*, *Phyllopezus przewalskii* (Phyllodactylidae), *Philodryas baroni* y *P. psammophidea* (Colubridae) en el departamento de Presidente Hayes; *Teius oculatus* (Teiidae), *Cercosaura schreibersii* (Gymnophthalmidae), *Amphisbaena mertensii* (Amphisbaenidae), *Boiruna maculata* y *Philodryas aestiva* (Colubridae) en el departamento de Caazapá; *Amphisbaena alba* (Amphisbaenidae) en los departamentos de Caaguazú y Cordillera; *Bothrops moojeni* (Viperidae), *Eunectes notaeus* (Boidae), *Helicops leopardinus* y *Hydrodynastes gigas* (Colubridae) en el departamento de Guairá; *Apostolepis dimidiata*, *Atractus paraguayensis* y

Mussurana bicolor (Colubridae) en el departamento de Itapúa; y *Epicrates crassus* (Boidae) y *Phalotris nigirilatus* (Colubridae) en el departamento de Concepción. Se documentan extensiones significativas del rango de especies amenazadas o poco conocidas: La distribución de *Salvator duseni* (Teiidae), en peligro, se extiende 128.5 km hacia el este dentro del departamento de Canindeyú; la de *Boa occidentalis* (Boidae), vulnerable, se extiende 109.2 km hacia el suroeste dentro del departamento de Boquerón; la de *Epicrates alvarezii* (Boidae), vulnerable, se extiende 136.6 km hacia el oeste dentro del departamento de Boquerón y 172.4 km al noreste hacia Alto Paraguay department; y la de *Caiman yacare* (Alligatoridae) se extiende 132 km hacia el oeste dentro del mismo departamento hasta el Río Pilcomayo. También se documenta un ejemplar adicional de la especie rara *Philodryas agassizii* (Colubridae) y confirmación de la existencia de la forma incierta *Phalotris "punctatus"* en Paraguay.

Werneburg, I. and Bronzati, M. (2024). Trifold origin of the reptilian ear ossicle and its relation to the evolutionary modification of the temporal skull region. *Journal of Anatomy* (doi: 10.1111/joa.14105).

Abstract: Whereas mammals are characterized by the presence of three middle ear ossicles, reptiles have only one, the columella (stapes). Nevertheless, there is a great diversity of columellar anatomy among sauropsids, especially in the unique and cartilaginous "extracolumella"-portion. Molecular studies revealed the "columella" of chicken and quails to be formed within the second pharyngeal arch, although conflicting evidence exists for the columellar footplate and distal parts of the columella in these birds. We studied columellar development in four turtles, one lizard, and one caiman species and argue, using early blastemata stages, that, distally, the so-called "extracolumella" in turtles is mainly of quadrate, that is, first pharyngeal arch origin. Differently, the dorsal aspect of the "extracolumella" of the lizard and a part of the "dorsal columella process" of the caiman are likely quadrate-derived. This indicates only a partial homology of the distal columellar compartments among reptiles. Moreover, we observed in most species that, at early stages, the footplate differentiates from the otic capsule, which confirms widespread experimental findings of mesodermal cells contributing to the proximal part of the columella. We provide a hypothetical framework for the changes in the columella and quadrate morphology in reptilian evolution. Originally, as evidenced by the fossil record, the columella served as a stabilizing brace between the quadrate and braincase. Associated with changes in the feeding mode of late Permian taxa, the quadrate was integrated along the stress flows from biting, and in early development part of the quadrate differentiated to differently contribute to the distal part of the "columella-complex," which now contacts the tympanic membrane. In addition, part of the original otic capsule contributes to the footplate of the mobile columella, providing a connection with the inner ear.

Dutton, H.R., Bullard, S.A., Brule, J.H. and Kelly, A.M. (2024). Redescription of *Dracovermis occidentalis* (Digenea: Liolopidae) infecting American alligator, *Alligator mississippiensis* from the Bon-Secour River (Mobile-Tensaw River Delta, Alabama, USA) and a revised phylogeny for Liolopidae. *Parasitology Research* 123(9) (doi: 10.1007/s00436-024-08339-2).

Abstract: We examined several American alligators, *Alligator mississippiensis* (Daudin, 1802) (Crocodylia: Alligatoridae) from Louisiana, Alabama, and South Carolina in August 2022. The intestine of one alligator from Alabama was infected by *Dracovermis occidentalis* Brooks and Overstreet, 1978 (Platyhelminthes: Digenea: Liolopidae Odhner, 1912), a seldom collected and incompletely described trematode that lacks a representative nucleotide sequence. Liolopidae comprises 5 genera and 15 species: *Liolope* spp. infect giant salamanders; *Helicotrema* spp. infect turtles and lizards; *Harmotrema* spp. infect snakes; *Paraharmotrema* spp. infect turtles; and *Dracovermis* spp. infect crocodilians. Based on our study of the newly collected specimens and the holotype of *D. occidentalis*, we

redescribe *D. occidentalis*, correct errors in its original description, and provide an updated phylogeny for Liolopidae that, for the first time, includes *Dracovermis* Brooks and Overstreet, 1978. Our specimens were identified as *D. occidentalis* by having testes in the posterior 1/3 of the body, a pretesticular cirrus sac, a spined and eversible cirrus, a bipartite seminal vesicle, and a post-acetabular vitellarium. A phylogenetic analysis of the D1-D3 domains of the nuclear large subunit ribosomal DNA (28S) recovered Liolopidae as monophyletic; however, low taxon sampling in the group precludes hypothesis-testing about liolopid-vertebrate cophyly. This is the first collection for morphological study of the type species for *Dracovermis* since the genus was proposed 46 years ago, the first record of a liolopid from Alabama, and the first phylogenetic analysis that includes *Dracovermis*.

Beloto, L.M., Lara, N.R.F., Bassetti, L.A.B., Littig, B.F., Ferreira, R.V.M., Verdade, L.M., Camargo, P.B. and Marques, T.S. (2024). Effects of anticoagulants time storage on stable isotope values of crocodilians' blood tissues. *Isotopes in Environmental and Health Studies* (doi: [10.1080/10256016.2024.2403655](https://doi.org/10.1080/10256016.2024.2403655)).

Abstract: Rapid coagulation of reptile blood often hinders its use in studies in remote and difficult-to-access areas, necessitating chemical preservation. Therefore, understanding the potential effects of anticoagulants on the isotopic compositions of blood is essential to avoid issues in interpreting the results for ecological studies. In this study we aimed to verify whether the storage time of the blood tissue in anticoagulants can influence its isotopic compositions of the broad-snouted caiman (*Caiman latirostris*), an ectothermic top predator from eastern South America. Blood samples were obtained from 10 adult females of *C. latirostris* from a commercial breeding facility in 2015. Samples were stored in vials containing ethylenediaminetetraacetic acid (EDTA) and sodium heparin (SH) and centrifuged after 2 and 8 h to separate red blood cells and plasma. No effect of time was found on the $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ of whole blood, plasma, and red blood cells in contact with the two types of anticoagulants, EDTA and SH. The findings have practical implications for researchers in this field, as they suggest that anticoagulants can be used effectively for at least 8 hours under refrigeration.

Rodrigues, J., Das, R., Barter, S., Pelosi, M. and Foster, W. (2024). Methodology for the thermoelastic stress analysis of complex biomimetic structures: An alligator mandible case study. *European Journal of Mechanics - A/Solids* (<https://doi.org/10.1016/j.euromechsol.2024.105450>).

Abstract: Biomimetic designs that take inspiration from natural structures provide a unique approach to identifying innovative solutions to engineering problems. The experimental analysis of such structures, however, can be difficult due to complex, three-dimensional geometric features. This study presents a methodology for the analysis of complex biomimetic structures using thermoelastic stress analysis (TSA) illustrated through an alligator mandible case study. This structure has evolved to become optimal for its function and environment which has resulted in unique and intricate features. An additively manufactured alligator mandible structure was experimentally analysed using TSA under bending load conditions and compared to a finite element (FE) solution. TSA was found to be a suitable method for the qualitative and quantitative analysis of the complex biomimetic structure which correlated well with the FE model. This study demonstrates the accuracy of TSA for the assessment of biomimetic designs with unique, arbitrary geometric features that can be utilised for future nature-inspired engineering applications.

Sofea, M.A., Eyrique, G., Tee, K.K. and Paul, A.G. (2024). Crocodile bite, a toil and snare of its own complexity - a single deep bite with multiple rippling impacts: A case report. *Manipal Alumni Science*

and Health Journal 9(1): 62-75.

Abstract: Crocodiles are ferocious creatures of the tropics. In East Malaysia, a total of 205 crocodile attacks were reported in 20 years. Most of these attacks occur in Sarawak (between 135 to 164 cases) and Sabah (70 cases) per annum (1). Though different species were found, reports have a common factor, attack on humans had led to significant morbidity and mortality. Crocodiles' bite causes fatal and non-fatal injuries. Once they lock their jaw, it is kept locked as its mouth-opening muscles are weaker. Another mechanism of destruction of the crocodile bite is the death roll - a rotating manoeuvre with the aim of dismembering their prey (2). The sheer force of this mechanism allows them to subdue victims larger than its own size. This case reports a victim of a crocodile attack leaving significant debilitation from its single bite. This paper also explores into understanding these creatures in its existence. A bite from the crocodiles leads to detrimental injuries especially to the extremities, giving the Orthopaedic Department a challenge to handle. Injuries from a crocodile bite has been recorded to range from extensive tissue damage, vascular injuries, fractures and even amputations (3). Once the injuries are dealt with, another obstacle to overcome is the severe bacterial infection that comes after the bite. Many bacterial species are found in the oral cavity of a crocodile, and most are polymicrobial with resistance to the common antibiotics used (4). We report our approach and management of this complex crocodile bite.

Ramchandani, M. and Muthu, S.S. (2024). Reconciling the sustainable consumer behavior dimensions: The lack luster of vegan leather in the luxury and fashion industry. Pp. 85-96 in *Vegan Alternatives for Leather. Sustainable Textiles: Production, Processing, Manufacturing & Chemistry*. Springer: Cham.

Abstract: As different challenges pertaining to producers, designers, and manufacturers were discussed in the previous chapters, the current chapter highlights the different consumer behavior dimensions pertaining to the luxury industry, including consumer-oriented goals and perceptions in sustainability, luxury, and fashion of vegan alternatives for leather. As luxury consumption may differ between vegans and non-vegans, separate distinctions of product-wise material categorizations (sustainable, non-sustainable, luxury, fashion) are identified and assigned to them. Furthermore, the chapter assesses how vegan leather lags behind in its appeal for luxury consumers when compared with conventional leather and where the divergence and convergence are necessary for brands to be able to innovate and find a place for vegan alternatives in the luxury industry.

El Bizri, H.R., Oliveira, M.A., Pessutti Rampini, A., Knoop, S., Fa, J.E., Coad, L., Queiroz Morcatty, T., Favero Massocato, G., Desbiez, A.L.J., Vitor Campos-Silva, J., La Laina, D.Z., Barbanti Duarte, J.M., Sá Leitão Barboza, R., Campos, Z., Basto da Silva, M., Mângia, S., Ingram, D.J. and Bogoni, J.A. (2024). Exposing illegal hunting and wildlife depletion in the world's largest tropical country through social media data. *Conservation Biology* 38: e14334.

Abstract: Globally, illegal sport hunting can threaten prey populations when unregulated. Due to its covert nature, illegal sport hunting poses challenges for data collection, hindering efforts to understand the full extent of its impacts. We gathered social media data to analyze patterns of illegal sport hunting and wildlife depletion across Brazil. We collected data for 2 years (2018-2020) across 5 Facebook groups containing posts depicting pictures of illegal sport hunting events of native fauna. We described and mapped these hunting events by detailing the number of hunters involved, the number of species, the mean body mass of individuals, and the number and biomass of individuals hunted per unit area, stratified by Brazilian biome. We also examined the effects of defaunation on hunting yield and composition via regression models, rank-abundance curves, and spatial interpolation. We detected 2046

illegal sport hunting posts portraying the hunting of 4658 animals (~29 t of undressed meat) across all 27 states and 6 natural biomes of Brazil. Of 157 native species targeted by hunters, 19 are currently threatened with extinction. We estimated that 1414 hunters extracted 3251 kg/million km². Some areas exhibited more pronounced wildlife depletion, in particular the Atlantic Forest and Caatinga biomes. In these areas, there was a shift from large mammals and reptiles to small birds as the main targeted taxa, and biomass extracted per hunting event and mean body mass across all taxonomic groups were lower than in other areas. Our results highlight that illegal sport hunting adds to the pressures of subsistence hunting and the wild meat trade on Brazil's wildlife populations. Enhanced surveillance efforts are needed to reduce illegal sport hunting levels and to develop well- managed sustainable sport hunting programs. These can support wildlife conservation and offer incentives for local communities to oversee designated sport hunting areas.

Reinhold, J.M. and Lahondère, C. (2024). Mosquitoes feeding on ectothermic hosts: from host seeking to pathogen transmission. *Current Opinion in Insect Science* (<https://doi.org/10.1016/j.cois.2024.101273>).

Abstract: While much research has centered on mosquitoes transmitting pathogens to mammals and birds, several species feed on cold-blooded hosts, including amphibians, reptiles, fish, and various invertebrates. Despite limited knowledge about these alternative feeding habits, delving into their biology offers valuable insights into the evolutionary origins of blood feeding and aids in developing comprehensive epidemiological models for vector-borne diseases. This review sheds light on these “alternative” hosts, highlighting recent discoveries in this field and probing into the evolutionary theories surrounding blood feeding in mosquitoes. Additionally, we delve into the host-seeking cues used by ectotherm-feeding mosquitoes and the physiological and mechanical challenges inherent in feeding on cold-blooded animals, contrasting them with endotherm-feeding mosquitoes. Finally, we examine the pathogens these mosquitoes can transmit. While our understanding of mosquitoes with alternative hosts remains incomplete, this review synthesizes existing knowledge, offering insights into the biology and ecology of mosquito species that target cold-blooded hosts.

Fasulkova, R., Strateva, M. and Stratev, D. (2024). Carcass characteristics, nutritional value and safety of crocodile meat. *Trakia Journal of Sciences* 3: 261-270.

Abstract: In the last few years, the European Union has reported increased imports of fresh, chilled or frozen meat, including crocodile meat. Industry has been developing and has invested largely in its efforts to improve quality and increase meat yield by innovating its methods of farming, feeding and carcass processing. The reason, on the one hand, is the fact that crocodile meat is perceived not only as “exotic” and “adventure”, but also as dietary and healthy, with high nutritional value, due to its low fat and sodium content and high protein percentage. The approximate composition of *Crocodylus niloticus* meat shows protein levels of 15.7-22.08%. In the other species *Crocodylus porosus*, *Caiman yacare*, *Alligator mississippiensis* and *Caiman latirostris* the average amount of protein is 20-21%, making it a food rich in protein, such as chicken, pork, lamb and beef. Crocodile meat contains high levels of monounsaturated fatty acids (MUFA) - between 33.2% and 51.3% and saturated fatty acids (SFA) - between 26.0% and 41.4%. It is quite delicate, with low cohesiveness, high elasticity and tenderness. It is juicy, without the presence of connective tissue with an intense taste and an almost imperceptible aroma. Iron, magnesium and sodium levels in crocodile meat are lower than those in beef and chicken. The low sodium content is another indication of the health benefits of crocodile meat. The paper dwells on the qualitative characteristics of crocodile meat, focusing on its safety as a product for human consumption and presents data about by-products obtained from crocodiles used in ancient and modern medicine,

beneficially affecting human health.

Andersen, D.K., Fischer, G.A. and Combrink, L. (2024). The alligator and the mosquito: North American crocodilians as amplifiers of West Nile Virus in changing climates. *Microorganisms* 12(9) ([doi: 10.3390/microorganisms12091898](https://doi.org/10.3390/microorganisms12091898)).

Abstract: In an age of emerging zoonoses, it is important to understand the intricate system of vectors and reservoirs, or hosts, and their relation to humans. West Nile Virus (WNV) has been detected in a myriad of nonhuman hosts. Transmission of the virus to humans is reliant on amplified seroprevalence within the host, which occurs primarily in birds. However, recent studies have found that other animal groups, including crocodilians, can obtain seroprevalence amplification to levels that make them competent hosts able to transmit WNV to mosquitoes, which can then transmit to humans. Climate change could exacerbate this transmission risk by shifting the distributions of mosquito vectors towards novel geographic ranges. Here, we use maximum entropy models to map the current and future distributions of three mosquito vector species and four crocodilian species in North America to determine the emerging risk of WNV outbreaks associated with changing climates and WNV associated with crocodilians in North America. From our models, we determined that one mosquito species in particular, *Culex quinquefasciatus*, will increase its distribution across the ranges of all crocodilian species in all tested climate change scenarios. This poses a potential risk to public health for people visiting and living near crocodilian farms and high-density natural crocodilian populations.

Johnson, M.M., Scheyer, T.M., Canoville, A. and Maxwell, E.E. (2024). Palaeohistology of *Macrospondylus bollensis* (Crocodylomorpha: Thalattosuchia: Teleosauroidea) from the Posidonienschiefer Formation (Toarcian) of Germany, with insights into life history and ecology. *The Anatomical Record* ([doi: 10.1002/ar.25577](https://doi.org/10.1002/ar.25577)).

Abstract: The Posidonienschiefer Formation of southern Germany has yielded an array of incredible fossil vertebrates. One of the best represented clades therein is Teleosauroidea, a successful thalattosuchian crocodylomorph group that dominated the coastlines. The most abundant teleosauroid, *Macrospondylus bollensis*, is known from a wide range of body sizes, making it an ideal taxon for histological and ontogenetic investigations. Previous studies examining thalattosuchian histology provide a basic understanding of bone microstructure in teleosauroids, but lack the taxonomic, stratigraphic, and ontogenetic control required to understand growth and palaeobiology within a species. Here, we examine the bone microstructure of three femora and one tibia from three different-sized *M. bollensis* individuals. We also perform bone compactness analyses to evaluate for ontogenetic and ecological variation. Our results suggests that (1) the smallest specimen was a young, skeletally immature individual with well-vascularized parallel-fibered bone and limited remodeling in the midshaft periosteal cortex; (2) the intermediate specimen was skeletally immature at death, with vascularized parallel-fibered bone tissue interrupted by at least 10 LAGs, but no clear external fundamental system (EFS), and rather extensive inner cortical bone remodeling; and (3) the largest specimen was skeletally mature, with parallel-fibered bone tissue interrupted by numerous LAGs, a well-developed EFS, and extensive remodeling in the deep cortex. *Macrospondylus bollensis* grew relatively regularly until reaching adult size, and global bone compactness values fall within the range reported for modern crocodylians. The lifestyle inference models used suggest that *M. bollensis* was well adapted for an aquatic environment but also retained some ability to move on land. Finally, both larger specimens display a peculiar, localized area of disorganized bone tissue interpreted as pathological.

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