

CROCODILE SPECIALIST GROUP NEWSLETTER

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CROCODILE

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GROUP

NEWSLETTER

VOLUME 42 Number 3
JULY 2023 - SEPTEMBER 2023

IUCN Species Survival Commission

CHAIR:

Professor Grahame Webb
PO Box 530, Karama, NT 0813, Australia

EDITORIAL AND EXECUTIVE OFFICE:

PO Box 530, Karama, NT 0813, Australia

Cover: Nile crocodiles (*Crocodylus niloticus*) at the "Croc Market", Lake Chamo, Ethiopia. Photograph: Ludwig Siegel.

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CSG Newsletter

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

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James Hennessy, The National Reptile Zoo, Ireland.

Cathy Shilton, Darwin, Australia.

Editorial

On 3 October, the CSG membership was informed that Professor Grahame Webb had stepped down as CSG Chair (see below). He also advised of our appointment by the SSC as the new Chairs of the group. To say that Grahame Webb is a “hard act to follow” is an understatement at best - his 20-year tenure as Chair has set the CSG on a firm foundation going into the future, on which we will continue to build.

On behalf of the CSG membership, we thank Grahame Webb for his tireless efforts to advance crocodylian conservation over the last 20 years as CSG Chair. But his contribution has not solely been at the level of the CSG, but also in the complex biopolitical arenas that are SSC/IUCN and CITES - indeed his entire professional career has been directed in one way or another at wildlife conservation issues.

On our part, we thank Grahame for his trust and confidence in our ability to lead the CSG. We look forward to working with the CSG membership to meet the challenges of crocodylian conservation in its varying contexts around the world.

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

Open Letter to CSG Members from Professor Webb

To all CSG members,

On 10 September 2023, I stepped down as Chair of the CSG, and would like to commend the SSC for its wisdom in appointing Charlie Manolis and Alejandro Larriera, as the new CSG Co-Chairs. With Sally Isberg as the new CSG Executive Officer, I am confident the CSG is in great hands, with institutional memory intact, and that it will continue to go from strength to strength in terms of championing crocodylian conservation. It will be up to the new Chairs to rearrange the CSG Executive and Steering Committees to best suit their vision for the future, and adapt to the continually changing priorities of the SSC and IUCN.

All CSG members have contributed to the CSG during my tenure as CSG Chair (20 years), obviously some much more than others. CSG is fundamentally a network of people with expertise in crocodylians, all employed privately, and all volunteering their time to something they consider worthwhile. To industry members a special thanks for assisting us, over so many years, to operate such a large group (currently 720 members), with no core funding from SSC or IUCN.

I would like to take this opportunity to thank all CSG members, for the support they have given me professionally and personally over so many years. I attended the 3rd CSG Working Meeting in 1977 but was excluded from CSG

membership because of political issues - mainly opposition by the CSG leadership of the day (and thus SSC and IUCN) to the concept that sustainable use could help conserve some crocodylian species.

This changed when Harry Messel assumed the CSG Chairmanship in the late 1980s, and accepted sustainable use as fundamental to conservation with some species. The rest is history. The policy on sustainable use adopted by the IUCN in 2020, after 10 years of deliberations, was an important milestone in which Hank Jenkins and myself played important roles.

During my Chairmanship I was inclusive rather than exclusive in appointing members, which proved a great strength overall, but had a few notable weaknesses. A fundamental part of becoming a CSG member was to establish “what can you do for the CSG?” We have had to struggle with some members, who saw membership only in terms of “what the CSG can do them personally?” In any overview, this was and should remain a minority. I’ve always felt it was professionally unethical for the CSG as a professional network of experts, to start using the formidable expertise within the network to start competing with its members for projects! The CSG’s role is to assist members trying to raise funds for their projects.

I personally believe that the key to conserving crocodylians lies in having “national champions” in all countries, implementing national programs, monitoring their progress, and dealing successfully with the multitude of social, cultural, political and economic variables involved in winning political support from their governments, the public, and the rural people living with crocodylians. This is the main strength of CSG membership. It is champions at the coal face that best conserve crocodylians, and not distant people in distant lands whose role should be to encourage and support.

I often ponder whether SSC or IUCN fully appreciate this fundamental reality within CSG (and some other Specialist Groups). CSG members with a few exceptions are professionals focused on crocodylians, with little experience, interest, credentials or time to contribute to the holistic and challenging tasks and initiatives that the SSC and IUCN pursue. These are highly specialised initiatives, in their own right, and were not what CSG members were appointed for or expected to be engaged in when they signed up to a species-specific Specialist Group such as the CSG.

Perhaps I am just too set in my ways to adapt personally to the increasingly complex biopolitics, agendas and interests that SSC now entails. So, I have personally withdrawn from SSC membership and IUCN completely, including other Specialist Groups of which I am a member. I will of course maintain my interest in crocodylians and other wildlife, and maintain the real friendships with the many genuine people, young and old, who are striving to implement practical conservation in the field or establish themselves so they can do so in the future.

Professor Grahame Webb, *CSG Chair (2004-2023)*.



27th CSG Working Meeting

Theme: Crocodile Conservation: What Works!

The Centre for Crocodile Research (www.crocresearch.com.au) is proud to host the 27th CSG Working Meeting in Darwin, Northern Territory, Australia, in April 2024. We cordially invite all people interested in crocodilians to attend this biennial event. The draft program is:

Day/Date	Program	Social Event
Sun, 14 April	Drone workshop, Veterinary workshop	
Mon, 15 April	Steering Committee meeting (and/or Morning Field Trip)	Welcome drinks
Tue, 16 April	Official welcome/working meeting (and/or Morning Field Trip)	Cocktail poster session
Wed, 17 April	Working meeting (and/or Morning Field Trip)	Gala dinner and auction
Thu, 18 April	Working meeting	
Fri, 19 April	Working meeting	Banquet
Sat, 20 April	Post-meeting Field Trip (Adelaide and Mary Rivers)	

Workshops: Drone and Veterinary Workshops being held on 14 April at Crocodylus Park are each limited to **50** participants - so register now to ensure your spot. The Drone Workshop will include demonstrations and discussion of current uses and advancements of drone technology and its application to crocodilian management and conservation. Lead co-ordinator: Dr. Matt Brien. The Veterinary Workshop will include presentations on topics such as surgical procedures, skin histology/quality, as well as a practical session on necropsy. Lead co-ordinator: Dr. Cathy Shilton.

Abstracts: Call for Abstracts for oral presentations and poster presentations was released on 1 October 2023. See www.csg2024.com for updates.

Morning Field Trips: Come along on this rare opportunity to accompany the Northern Territory Crocodile Management Team as they conduct their routine patrols of Darwin Harbour as part of the program to keep the public safe. These field trips can be booked for Monday, Tuesday or Wednesday morning. You will be back at the conference venue by midday to participate in the remaining working meeting schedule. Limited to **12** people per day.

Field Trip: The post-meeting field trip on 20 April promises to be awesome, but is limited to **98** participants - be quick to register your spot! Participants will partake in cruises on two of the most densely Saltwater crocodile populated rivers in the Top End of Australia - the Adelaide River (Jumping Crocodile Cruise) and Corroborree Billabong (Mary River).

Meeting Website: Details on accommodation, venue, registration (including Early Bird discounts), etc., are available at: www.csg2024.com. More details will be released as the Organising Committee continues to be humbled by sponsors, donations and offers of assistance to make this conference a tremendous success!

We look forward to seeing you in Darwin in April 2024.

Dr. Sally Isberg, Chair of Organising Committee (sally@crocresearch.com.au)

Conference Cycle on Human-Crocodile Conflict in Latin America & the Caribbean

This year, Paulino Ponce Campos celebrates 30 years working with Human-Crocodile Conflict (HCC) in Mexico and other parts of Latin America. To celebrate, a virtual conference series (1st Online Conference Cycle: 30th Anniversary of “Human-Crocodile Interactions in Mexico” 1993-2023) has been set up, to cover the topic of HCC in the Americas and the Caribbean. It is anticipated that after this conference cycle, others will be presented for other regions.

At the time of writing, some presentations had already been broadcast:

6 September 2023

- Grahame Webb and Charlie Manolis: Introduction.
- Gustavo Sosa Rodríguez (Cuba): Interacciones entre el hombre y el cocodrilo cubano en la Ciénaga de Zapata, Cuba.
- Trey Picking (Jamaica): The state of human-crocodile interactions in Jamaica.

Cuba and Jamaica can be viewed at: <https://www.facebook.com/paulino.ponce.5/videos/1793547464394184>.

27 September 2023

- Valerie Garcia and Diana Velásquez (Guatemala): Understanding the dynamics of the Crocodile-Human Conflict in Guatemala: Influential factors and first official records.
- Marisa Tellez (Belize): Building community pride and stewardship to further crocodile coexistence.

Guatemala and Belize can be viewed at: <https://www.facebook.com/paulino.ponce.5/videos/1525747171562111>.

Additional presentations will be broadcast on 25 October, 15 November and 6 December 2023 (see below). These will be live streamed (no login required). Facebook page is open to the public: <https://www.facebook.com/paulino.ponce.5/>.

25 October 2023

- Armando Rubio Delgado (México): Domestic animals-crocodiles interaction in Puerto Vallarta and Banderas Bay, Mexico.
- Laura Porras Murillo (Costa Rica): From the field, to paper, to action. What is missing in the management of negative interactions between humans and crocodiles.

15 November 2023

- Ronis Da Silveira (Brazil): *Melanosuchus niger* as the pivot of the Human-Caiman Conflict in Brazil.
- Paulino Ponce Campos (México): 30 years of research on HCC in Mexico.

6 December 2023

- Allan Woodward (USA): HCC with American alligator in USA.
- Simon Pooley (UK): Progressing beyond incident response

in tackling Human-Crocodile Conflicts.

- Simon Pooley, Allan Woodward, Pablo Siroski and Hesiquio Benítez: Closure

In Memoriam

Pedro Vásquez Ruesta (1954-2023)

Our friend Pedro Vásquez Ruesta, a CSG member since 1982, passed away in late August 2023. Pedro graduated from the National Agrarian University of La Molina, Lima, Peru, as a forestry engineer, and dedicated his life to the conservation of natural resources. He also belonged to the IUCN Commission on National Parks and Protected Areas, and worked for the last 40 years in regional planning, wildlife management and natural resource management.



Since 1976, Pedro was a professor in the Department of Forest Management of the Faculty of Forestry Sciences, at the National Agrarian University of La Molina (UNALM), having reached the rank of senior professor in 1996. He was also founder and director of the Data Center for Conservation (CDC) at that university. For decades, he was in charge of the chairs of natural resources of Peru, wildlife and national parks, wildlife management, management of protected natural areas and management of natural areas.

Pedro was, above all, an exemplary teacher who knew how to infect hundreds of students with his passion for wildlife management and the conservation of natural ecosystems. Your student friends will not forget it. He wrote more than 40 articles about his different research, ranging from birds to his posthumous work, a book on the Gray-tailed deer (*Odocoileus virginianus*).

Source: Ana Maria Trelancia, Lima, Peru.

Hank Jenkins (1947-2023)

On 16 September 2023, Robert William Garfield Jenkins - better known within CSG and CITES circles as “Hank” Jenkins - passed away in Canberra, Australia, with family by his side. He had just turned 76 years of age. Hank was more subdued than normal at CITES CoP19 in Panama (November 2022), and was diagnosed with cancer on his return to Australia. He remained sharp and humorous through various treatments, right up to the end.



Hank was born in England (19 August 1947) and his family migrated to Australia as “Ten Pound Poms” in the 1950s. He was a keen herpetologist, who almost died from a Tiger snake bite as a teenager. He completed a BSc in Zoology at the Australian National University, and one of his first jobs was with the Commonwealth Scientific and Industrial

Research Organisation (CSIRO) in Canberra, working out how to breed dung beetles. The program was so successful in controlling flies, that millions of urban people have benefitted from his work.

Hank joined the Australian National Parks and Wildlife Service (ANPWS; Australia's CITES Management and Scientific Authority) in 1976, when CITES was just coming into force, and with the exception of 3 years working for the Northern Territory Conservation Commission (1987-89), he remained with ANPWS and its later iterations, until 2020, when he retired from the position of Director, International Programs Unit. He then formed an NGO, Creative Conservation Solutions, through which he remained active on CSG and CITES issues.

Hank's history with the CSG was a somewhat complicated one. He was appointed as a member in the late 1970s, when the dominant CSG ethos was protectionism and anti-trade, with begrudging support for closed-cycle captive breeding, and opposition to ranching or wild harvest. As a zoologist, Hank was carrying out a long-term field study of Saltwater crocodiles (*Crocodylus porosus*) in Kakadu National Park, working closely with indigenous people, at the same time that Professor Harry Messel's program was operating in the Northern Territory.

Through ANPWS, Hank was involved with efforts to downlist the Australian population of *C. porosus* from Appendix I to Appendix II, which began in 1983 and were successful in 1985, despite determined opposition from the CSG and IUCN. At the 1984 CSG Working Meeting (Caracas, Venezuela), Hank refused to alter the minutes of a meeting, and was expelled from the CSG by the Chair (the late Professor Wayne King). He thus joined Grahame Webb and Charlie Manolis as people excluded from the CSG because of their support for sustainable use as an effective conservation solution for some species, in some contexts. This all reverted in the late 1980s, when Harry Messel took over as CSG Chair and accepted a role for sustainable use approaches.

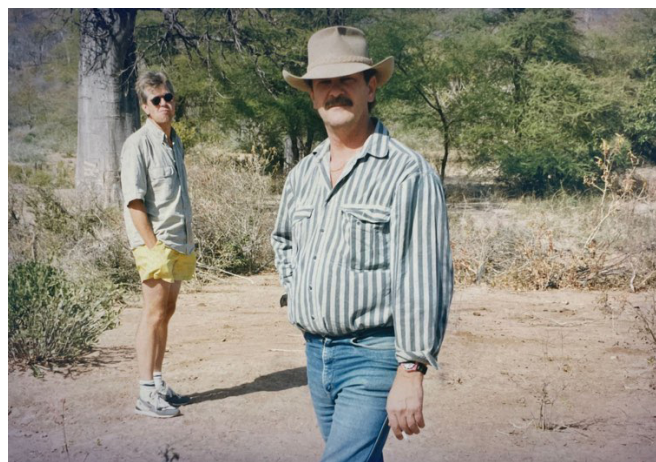


Figure 1. Hank Jenkins (foreground) at the 1992 CSG Working Meeting at Victoria Falls, Zimbabwe. Dr. Dietrich Jelden is in the background.

Within the CSG, Hank helped so many CSG members gain a better understanding of CITES and sustainable use. As a member of the Australian CITES Management Authority from the earliest days of CITES, Hank was well-versed with the text of the Convention, and participated in many of the processes and working groups leading to Resolutions interpreting the text. He was elected as Oceania representative to the CITES Animals Committee (AC) at CoP7 (1989), and served as Animals Committee Chair from CoP8 (1992), until CoP11 (2000).

As AC Chair, Hank's international travel schedule was simply daunting, as were the diversity of specialist areas with which he had to become familiar. He proved to have tremendous skills in facilitating meetings of Parties and NGOs, to resolve pathways for moving forward, even when issues were highly controversial and subject to diametrically opposed opinions. He was in many ways a natural diplomat, with the capacity to interact and network with a huge number of people. He attended 15 CITES CoPs, and gave freely of his knowledge and experience to the CSG.

Outside of the formal side of CSG and CITES meetings, and of the multitude of other meetings Hank was invited to attend or Chair, he was a seriously fun guy to know and interact with. He was available to anyone who sought his opinion on issues, and shared social fun with anyone present, with the same smile and sense of humour and "mateship". There was clearly a socially challenging side of Hank for some, as he was just as likely to turn up to a meeting in his colourful "happy pants", with an emerald earring and dyed blonde hair, and become fully engaged in whatever direction a social function took. There are simply so many humorous stories involving Hank, from so many people from so many countries, and linked in one way or another to CITES, who have laughed with him. He was truly a "valued personality".

As a strong supporter of sustainable use, who respected the diversity of different values different people attribute to wildlife, after his retirement he devoted most of his energy to assisting Parties which he genuinely felt were being harshly treated by the sometimes complex biopolitics of CITES. He was quite fearless in wading into controversial debates, and advising Parties and others on the strengths and weakness of various issues that would be voted upon. In any overview, he researched issues closely, and spoke openly and frankly when asked for advice. So many condolences received by his family, thank Hank for the lessons they learned from him, and for the technical assistance he provided to Parties.

Hank loved his life much, and seems to reflect much of what Lord Alfred Tennyson describes in his poem "Ulysses". He has left a remarkable legacy, and will be missed by so many.

Source: Grahame Webb (gwebb@wmi.com.au).

World Trade in Crocodilian Skins

The latest report on international trade in crocodilian skins since 2012, with particular focus on the 2019-2021 period, is now available. This is the 29th report produced by UNEP-WCMC for the International Alligator and Crocodile Trade Study (IACS). Data were obtained from the CITES Trade Database maintained by UNEP-WCMC on behalf of the CITES Secretariat, with additional information provided by the Crocodile Farmers Association of Zimbabwe (CFAZ) and the United Nations Food and Agriculture Organisation (FAO).



Citation: Caldwell, J. (2023). World Trade in Crocodilian Skins 2019-2021. UNEP-WCMC: Cambridge.

“The Current Paradigms in the Conservation and Use of Crocodilians in Latin America” Symposium (20-24 November 2023)

The Symposium will be held on 20-24 November 2023, in Santa Marta, Colombia, under the auspices of the International Congress on Management of Wildlife in Amazonia and Latin America (www.comfauna.org/xvcimfauna-congreso-2023). The general objective of the Congress is to strengthen the participation of local communities in the exchange of knowledge on the sustainable management of wildlife in Latin America.

Abstracts for the Symposium can be submitted by e-mail to Robinson Botero Arias (robincrocs@gmail.com), and following XVCIMFAUNA guidelines (www.comfauna.org/xvcimfauna-congreso-2023).

In order to participate in the Symposium, participants must have registered for the Congress. Don't miss the opportunity to share your ideas and contribute to the conservation of crocodilians in Latin America!



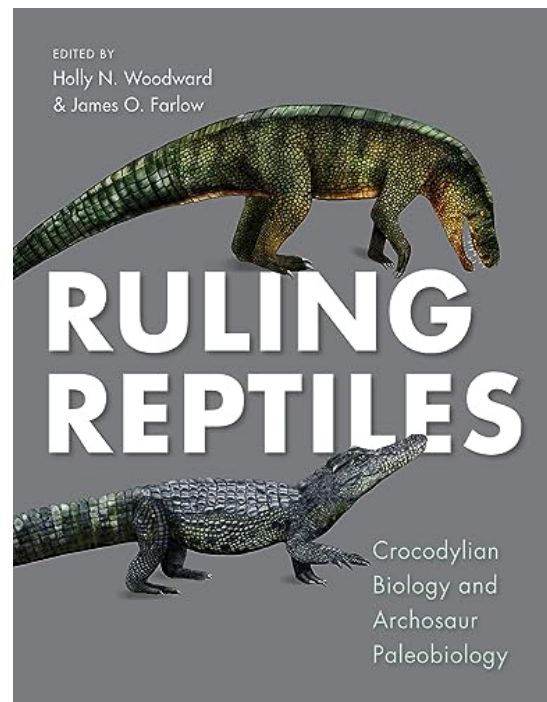
CSG Student Research Assistance Scheme

The Student Research Assistance Scheme (SRAS) and Fritz Huchzermeyer Veterinary Science Student Research Assistance Scheme (FHVS-SRAS) provided funding to four students in the July-September 2023 quarter (see below), and four applications are currently under review.

1. Yanick Hendriks (Denmark): Evaluation of the population and distribution of the American crocodile (*Crocodylus acutus*) in Placencia Lagoon, Belize.
2. Monica Perez (Mexico): Genetic flow between insular and mainland Caribbean crocodiles: Allopatry, forced hybridization, or continuous flow.
3. Cesar Leal (Mexico): Persistent organic compounds as endocrine disruptors of *Crocodylus moreletii* in conserved and urban environments of Mexico.
4. Albert Wilken (South Africa): Comparing UAV and spotlight surveys for Nile crocodile population monitoring in southern Africa.

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

Books



“Ruling Reptiles: Crocodylian Biology and Archosaur Paleobiology” (2023), edited by Holly Woodward and James Farlow, features 19 contributions on a range of topics on crocodylian evolution and biology, including osteology, osteohistology, developmental biology, myology, odontology, functional morphology, allometry, body size estimation, taphonomy, parasitology, ecology, thermophysiology, and ichnology.

Modern crocodylians have evolved over some 250 million years, and are the only living members of the Archosauria. “Ruling Reptiles” demonstrates how these types of studies can also provide crucial insights into dinosaurian biology and evolution. “Ruling Reptiles” is available as an ebook (<https://iupress.org/9780253066473/ruling-reptiles/>), and is recommended reading for zoologists, biologists, paleontologists and enthusiasts alike.

Chapter titles:

1. Farlow, J.O. and Woodward, H.N. (2023). Ruth M. Elsey and alligators: An appreciation.
2. Araújo, R. and Fernandez, V. (2023). Three-dimensional developmental atlas of the *Crocodylus niloticus* skeleton.
3. Johnston, P.S. (2023). The hyolingual apparatus of crocodylians: Functional anatomy and evolutionary history.
4. Langel, C.R. and Bonnan, M.F. (2023). Ontogenetic changes in the cross-sectional geometry and deltopectoral crest of the humerus in *Alligator mississippiensis*.
5. Wilhite, R. (2023). A detailed anatomical study of the M. caudofemoralis longus in *Alligator mississippiensis*.
6. Böhmer, C. (2023). Bridging the gap between fossils and genes in archosaurs: Molecular backbone of dinosaur necks.
7. Keenan, S.W. and Tellez, M. (2023). Symbiotic associations in crocodylians: Present, past, and future.
8. Wheatley, P.V., Haupt, R.J. and Hastings, A.K. (2023). Estimating total length from tooth size in *Alligator mississippiensis*.
9. Drumheller, S.K., D’Amore, D.C. and Njau, J.K. (2023). Taphonomic approaches to bite-mark analyses in the fossil record and applications to archosaurian paleobiology.
10. Haupt, R.J. and Hastings, A.K. (2023). Analysis of fossil crocodylian teeth as a potential indicator of past nesting sites or juvenile refugia: A test case from the Miocene of Panama.
11. Gomes de Souza, L., Vargas Pêgas, R., Da Silva Lacerda, M.B. and Riff, D. (2023). Tales of long faces: Piscivorous archosauriformes and the evolutionary ways to form a fisher.
12. Brink, K.S. and LeBlanc, A.R.H. (2023). How the study of crocodylian teeth influences our understanding of dental development, replacement, and evolution in dinosaurs.

13. Cullen, T.M. (2023). Stable isotopic analyses of living and extinct crocodylians: Implications for understanding their biology, environments, and physiology.
14. Bailleul, A.M. and Schweitzer, M.H. (2023). Skeletal tissues of crocodylians: Evolutionary insights for the biology of non-avian dinosaurs and other extinct archosaurs.
15. Audije-Gil, J., Barroso-Barcenilla, F. and Cambra-Moo, O. (2023). Mapping histovariability and growth patterns of *Crocodylus niloticus* bred in captivity and its paleobiological implications.
16. Woodward, H.N., O’Brien, H.D. and Farlow, J.O. (2023). Alligator allometry, osteohistological correlates, and paleobiological applications.
17. Brice, P. and Grigg, G. (2023). Modelling gigantothermy endorses the tachymetabolic, constitutional endothermy of ichthyosaurs, mosasaurs, and plesiosaurs (Sauropsida).
18. Seymour, R.S. (2023). Physiology and anatomy of extant crocodiles as windows to pseudosuchian evolution.
19. Farlow, J.O., Kumagai, C.J. and Klein, H. (2023). Alligators, crocodiles, and chirotheres: Within-taxon and across-taxon variability in ichnologically relevant autopodial and other body proportions.

Book Citation: Woodward, H.N. and Farlow, J.O. (Eds.) (2023). Ruling Reptiles: Crocodylian Biology and Archosaur Paleobiology. Indiana University Press: Bloomington, Indiana.

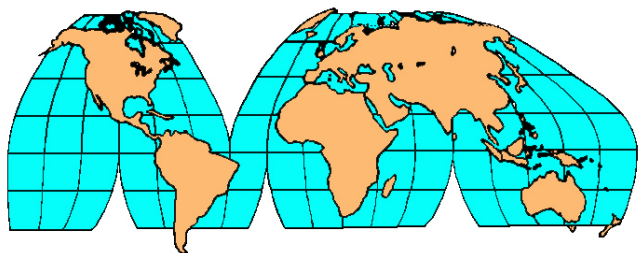
Source: <https://www.amazon.com/Ruling-Reptiles-Crocodylian-Archosaur-Paleobiology-ebook/dp/B0B6ZV67KH>.

Biology of the Reptilia

The Gans Collections and Charitable Fund (<https://carlgans.org/>) is a private foundation established by Professor Carl Gans (1923-2009) to continue his work in biology. The Fund’s efforts include making the works of Carl Gans available to the public in the widest possible manner, now including free online publication of “Biology of the Reptilia”.

The 22 volumes (13,800 pages) of “Biology of the Reptilia”, covering behavior, development, ecology, neurology, physiology and morphology, have been digitised and are available online at: <https://carlgans.org/biology-reptilia-online/>. Any page of the extensive content can be viewed online.

Regional Reports



South Asia and Iran

India

PRELIMINARY OBSERVATIONS ON HOME RANGE AND TEMPERATURE SELECTION IN THE MUGGER CROCODILE (*CROCODYLUS PALUSTRIS* LESSON, 1831) IN A HUMAN-DOMINATED LANDSCAPE. Little is known of the home range and body temperature of the Mugger crocodile (*Crocodylus palustris*). Vyas and Bhavsar (2009) reported on a rescued crocodile returning to its capture site, and Singh (1983) reported on movements of two Muggers released into the wild. With regard to temperature selection in *C. palustris*, Tibbo (1991) studied basking patterns at Madras Crocodile Bank. Venugopal and Prasad (2003) studied temperature selection in a wild Mugger population in Ranganthit National Park, Karnataka State. Gupta and Hari (1991) observed basking behaviour in this species in Bhorsainda Crocodile Sanctuary, Haryana State. Whitaker *et al.* (2007) examined temperature variation in tunnels inhabited by *C. palustris* in Sri Lanka. More recently, Whitaker and Srinivasan (2021) examined thermal selection in a group of Muggers at Madras Crocodile Bank.

Here, we report on home ranges and thermal selection of five adult Muggers in the Cauvery River in Anakarai (11.135946°N, 79.448356° E), Tamilnadu. The town is adjacent to the Lower Anicut Dam, divided into North and South Dams (Fig. 1). Both dams were constructed for irrigation purposes in the early 1900s during the period of colonial rule. Annual air temperature in the region averages around 28°C, and rainfall occurs in the southwest monsoon (April-September) and the northeast monsoon (October-December) when most rain occurs. The warmest month of the year is May, with an average temperature of 31.5°C, with average maximums and minimums of 37.2°C and 27.8°C, respectively (Premke *et al.* 2020).

After obtaining the necessary permissions from the Central and State Governments, two male and three female adult Muggers were captured in June 2019, and radio-tracked until March 2020 (see Fig. 1). The transmitters [151 MHz; Advanced Telemetry Systems (ATS), USA] were attached to the first crests of the double caudal whorls (scutes), following the methodology of Lang and Whitaker (2010) as used for Gharial (*Gavialis gangeticus*). The receivers used were ATS-fm16 and Telonics Tr-4, with three- and five-element antennas.



Figure 1. Study area, showing North and South Dams, and initial capture site (an isolated pond below South Dam).

Transmitters recorded air and/or water temperatures, and so these (termed environmental temperature; TE) are considered as a proxy for Mugger body temperature (eg Downs *et al.* 2008) with *C. niloticus*).

Roads, tracks and highways overlooking Anakarai Dam were used as points to search for the presence of tagged crocodiles. Air temperature was recorded using a Realtek™ thermohydrometer. Air and TE were recorded between 0700 and 1900 h. The purchase of a Garmin Extrex Vista HCx GPS in January 2020 allowed coordinates to be obtained.

We had planned to track the crocodiles from July 2019 until the transmitter batteries died. However, tracking the animals proved problematic, as a discharge of thousands of cubic metres of water coincided with the northeast monsoon, that filled the dam. Initial locations recorded on 2 July 2019 placed all five crocodiles below the dam. Subsequently, there were only 8 readings (2 each for 4 animals) up until 23 October 2019 (Fig. 2). Surveys were not carried out in November and December 2019 due to a lack of funds.

Between 1 January and 28 March 2020, approximately 550 people-hours were spent recording thermal and location data. The most consistent data were collected for one male and two females (Table 1; Figs. 3-5). Home ranges were calculated using the minimum convex method (White and Garrot 1990), which encompasses the most outlying points.

The low sample sizes do not allow for comparing crocodile gender or size. However, the two female Muggers moved within areas of 0.71 and 1.63 km² respectively, whereas the male's area was 0.68 km². This difference may relate to the beginning of the nesting season, with females searching for nest sites (Muggers in South India are known to lay eggs between February and May; Lang *et al.* 1989). This is supported by a crocodile (presumably a female) that we observed beside a burrow/tunnel on 17 March 2020, aggressively defending the area from people harassing it, indicating there may have been a nest nearby (Fig. 6).

Unfortunately the period of study did not span a full year, and thus cover all seasons. Nor did surveys cover night time. For the 3-month period, crocodiles stayed within the same



Figure 2. Locations (N= 2 each) of 4 Muggers (Channels 4, 8, 10, 15; Table 1), 2 July-23 October 2019.

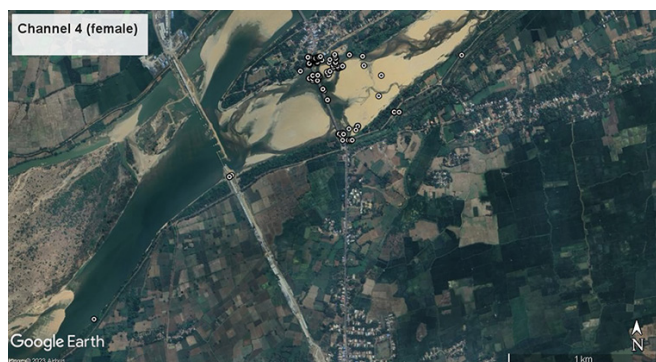


Figure 3. Locations for female Mugger (Channel 4; Table 1), 15 January-23 March 2020.

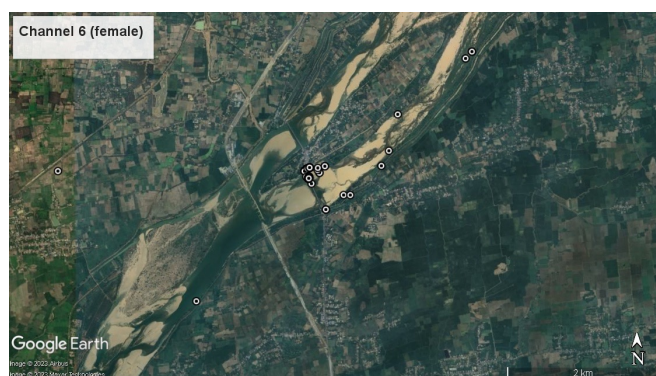


Figure 4. Locations for female Mugger (Channel 6; Table 1), 15 January-23 March 2020.

areas in which they were initially captured. The area could be favourable due to a high prey base in the form of domestic animals and proximity to a meat market where trash fish (eg catfish *Clarius* sp.) are discarded on the banks of the river.



Figure 5. Locations for male Mugger (Channel 8; Table 1), 15 January-24 March 2020.



Figure 6. Burrow observed on 17 March 2020.

Strong anthropogenic pressure in the form of fishing with cast nets, river crossings by humans and livestock, and harassment by residents (stone throwing). This may also affect areas which crocodiles avoid, due to human disturbance (discussed by Ezat *et al.* 2020 for the Nile crocodile). These disturbances may explain the low number of transmitter fixes with the other three crocodiles.

Man-made irrigation ditches, water tanks and water draining from the dam meant that line of sight was often lost. Individual experiences with humans leading to wariness or habituation may have also played a role. A significant drawback was that we could not make visual observations of the radio-tagged Muggers and record these in conjunction with TE, as was done by Grigg and Kirshner (2015).

For the three Muggers for which there were consistent data, mean TE (between 0700 and 1900 h) was lower than mean air temperature (see Figs. 7-9; Table 2), and this was found to be significant (ANOVA, $F= 74.54$, $df= 4$, $p<0.00$).

Table 1. Details on Muggers tracked in January-March 2020. * Muggers excluded from analysis due to limited data; TL= total length; SVL= snout-vent length.

Channel	Sex	Frequency (MHz)	TL/SVL (cm)	Home Range (km ²)	No. of Readings Attempted	No. of Locations with TE
4	Female	151.666	232/140	0.71	320	319
6	Female	151.685	292.5/158	1.63	52	52
8	Male	151.705	295/168	0.68	323	317
10	Male*	151.724	256/142	22.8	435	17
15	Female*	151.773	201/-	-	433	5

There was no significant relationship between accumulative TE and air temperature for the three crocodiles (ANOVA, $F = 134.7$, $df = 630$, $p < 0.00$), indicating that crocodiles were regulating their body temperature by behavioural means (ie moving to deeper water to cool down and basking to heat up). Relative to air temperatures, fluctuations in TE were lower (Table 2; Figs. 7-9).

Table 2. Mean TEs and air temperatures, and ranges (in brackets), January-March 2020. Number next to sex indicates Channel Number. See Figs. 7-9.

Sex/ID	Mean TE (°C)	Mean Air (°C)	N
Female 4	27.7 (24.7 to 37.7)	29.6 (26.2 to 40.1)	326
Female 6	28.1 (25.6 to 37.4)	30.1 (26.5 to 37.6)	44
Male 8	27.8 (24.6 to 36.2)	29.6 (26.3 to 40.1)	320

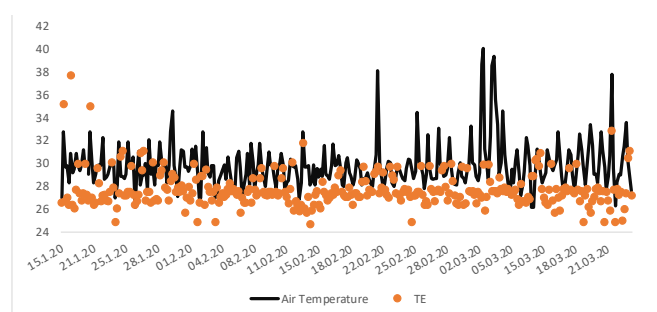


Figure 7. Air temperature (black line) and TE (dots) for female Mugger (Channel 4; Table 1), 15 Jan-24 Mar 2020.

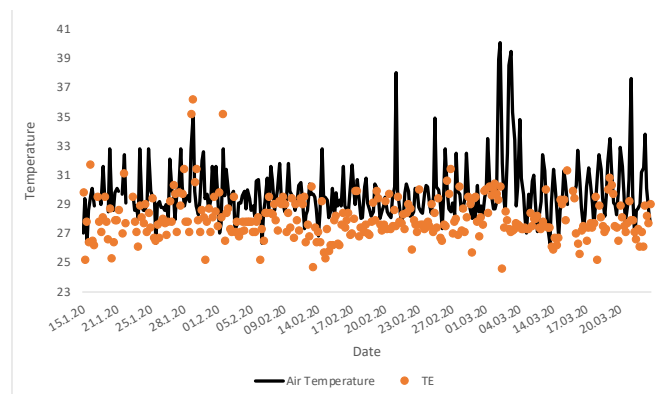


Figure 8. Air temperature (black line) and TE (dots) for male Mugger (Channel 8; Table 1), 15 Jan-24 Mar 2020.

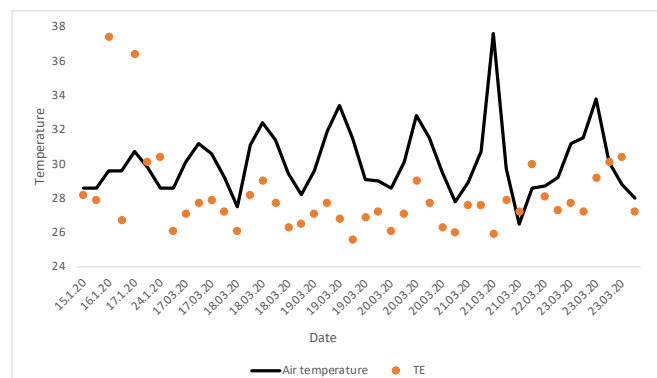


Figure 9. Air temperature (black line) and TE (dots) for female Mugger (Channel 6; Table 1), 15 Jan-24 Mar 2020.

An assumption that we made is that TE is a good representation of body temperature. TEs of 33+°C could be associated with basking, and those around 26°C could be related to crocodiles being on the water surface or in shallow water. Another variable to consider is that the transmitters stop sending signals when immersed in more than one metre of water (Jailabdeen A., pers. comm.).

A more thorough analysis could be conducted in captivity, using both external transmitters and internal data loggers, as the relationship between the two is strong (eg Audet and Thomas 1996; McCafferty *et al.* 2015). Furthermore, to improve the actual location of crocodiles, a method described by Koehn *et al.* (2018) could relate signal strength to transmitter distance. This could be standardised prior to transmitter attachment.

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Literature Cited

- Audet, D. and Thomas, D.W. (1996). Evaluation of the accuracy of body temperature measurement using external radio transmitters. *Canadian Journal of Zoology* 74: 1778-1781.
- Downs, C.T., Greaver, C. and Taylor, R. (2008). Body temperature and basking behaviour of Nile crocodiles (*Crocodylus niloticus*) during winter. *Journal of Thermal Biology* 33(3): 185-192.
- Ezat, M., Naguib, M. and Van Langevelde, F. (2020). Home range and long-range movements of the Nile crocodile in relation to the anthropogenic pressure, Lake Nasser, Egypt. Pp. 76 in *WIAS Annual Conference 2020: Frontiers in Animal Sciences*. WAC: Netherlands (<https://edepot.wur.nl/519102>).
- Gupta, R.C. and Hari, P.S. (1989). On the basking behaviour of the mugger *Crocodylus palustris* at Bhorsainda Crocodile Sanctuary, Haryana, India. *Journal of the Bombay Natural History Society* 86(2): 170-174.
- Grigg, G. and Kirshner, D. (2015). *Biology and Evolution of Crocodylians*. CSIRO Publishing: Australia.

- Lang, J.W., Andrews, H. and Whitaker, R. (1989). Sex determination and sex ratios in *Crocodylus palustris*. *American Zoologist* 29(3): 935-952.
- Lang, J.W. and Whitaker, S. (2010). Application of telemetry techniques in crocodilian research: Gharial (*Gavialis gangeticus*) spatial ecology in the Chambal River, India. *Telemetry in Wildlife Science, ENVIS Bulletin: Centre on Wildlife & Protected Areas Bulletin* 13: 161-170.
- Koehn, J.D., Eiler, J.H., McKenzie, J.A. and O'Connor, W.G. (2011). An improved method for obtaining fine-scale location of radio tags when tracking by boat. Pp. 379-384 in *Advances in Fish Tagging and Marking Technology*, ed. by J. McKenzie, B. Parsons, A. Seitz, R. Kopf, M. Mesa and Q. Phelps. American Fisheries Society, Symposium 76: Bethesda, Maryland.
- McCafferty, D.J., Gallon, S. and Nord, A. (2015). Challenges of measuring body temperatures of free-ranging birds and mammals. *Animal Biotelemetry* 3: 33.
- Premke, K., Dharanivasan, G., Steger, K., Nitzsche, K.N., Jayavignesh, V., Nambi, I.M. and Seshadri, S. (2020). Anthropogenic impact on tropical perennial river in South India: Snapshot of carbon dynamics and bacterial community composition. *Water* 12(5): 1354.
- Singh, L.A.K. (1983). Observations on the movement of two captive-reared mugger crocodiles, *Crocodylus palustris* Lesson when returned to the wild. *Journal of the Bombay Natural History Society* 80(1): 86-90.
- Tibbo, K. (1991). Thermoregulatory and Social Behavior of Muggers in Captivity. Report submitted to Madras Crocodile Bank Trust, Vadanemmel, India. 33 pp.
- Venugopal, D.P. and Prasad, K.V.D. (2003). Basking behavior and survey of Marsh crocodiles *Crocodylus palustris* (Lesson, 1831) Ranganthittu Bird Sanctuary, Karnataka, India. *Hamadryad* 27(2): 241-247.
- Vyas, R. and Bhavsar, S.R. (2009). Movement of an individual Mugger into urban areas of Vadodara City, Gujarat State, India. *Crocodile Specialist Group Newsletter* 28(3): 5-7.
- Whitaker, R., Barr, B., Silva, A.D. and Ratnasiri, P. (2007). Observations on burrows dug by mugger crocodiles (*Crocodylus palustris*) in Bundala National Park, Sri Lanka. *Journal of the Bombay Natural History Society* 104(2): 19-24.
- Whitaker, N. and Srinivasan, M. (2018). Preliminary observations on deep body temperatures in female Mugger crocodiles (*Crocodylus palustris* Lesson:1831) in a captive facility. *International Journal of Current Microbiology and Applied Sciences* 7(12): 2835-2842.
- White, G.C. and Garrot, R.A. (1990). *Analysis of Wildlife Radio-tracking Data*. Academic Press: New York, USA.
- Nikhil Whitaker¹, Jason Gerard² and R. Surya³: ¹Curator, Madras Crocodile Bank Trust/Centre for Herpetology, P.O. Box 4, Mamallapuram, Tamil Nadu-603104, India (nikhil@madrascrocodilebank.org); ²Post Box #18, Chandrabani Dehradun-248001, Uttarakhand, India; ³WCS India, 551, 7th Main Road, 2nd Phase, Kodigehalli, Bengaluru, Karnataka-560097, India.

PREDATION OF ESTUARINE CROCODILES (*CROCODYLUS POROSUS*) BY WHITE-BELLIED SEA EAGLES (*HALIAEETUS LEUCOGASTER*) IN BHITARKANIKA NATIONAL PARK OF ODISHA, INDIA. Behura and Kar (1981) reported predation of Estuarine crocodile (*Crocodylus porosus*) eggs by Wild boars (*Sus scrofa*), Water monitors (*Varanus salvator*) and Indian pythons (*Python molurus*) in Bhitarkanika National Park/Sanctuary (BNP), and Choudhury and Bustard (1980) highlighted predation of nests on Northern Andaman Island. In BNP, predation of hatchling and yearling *C. porosus* by Long whiskered catfish (*Mystus gulia*), Water monitors (*V. salvator*), Grey herons (*Ardea cinerea*), Large egrets (*A. alba*), Greater bandicoots (*Bandicota indica*) and Grey mongoose (*Herpestes edwardsi*) have been observed and documented.

With regard to raptors, predation of hatchling *C. porosus* by White-bellied sea eagles (*Haliaeetus leucogaster*) has been reported by Gopi and Pandav (2006) and Palei *et al.* (2019) in BNP (Fig. 1). The sea eagle is a prominent member of the avifauna assemblage of BNP (Singh and Kar 2021). Palei *et al.* (2014) estimated the population to be 17-20 individuals in 2007, and the population was estimated at about 30 individuals in 2021 (S.K. Kar, unpublished data). *Haliaeetus leucogaster* is on Schedule 1 of the *Indian Wildlife (Protection) Act 1972* and Appendix II of CITES.

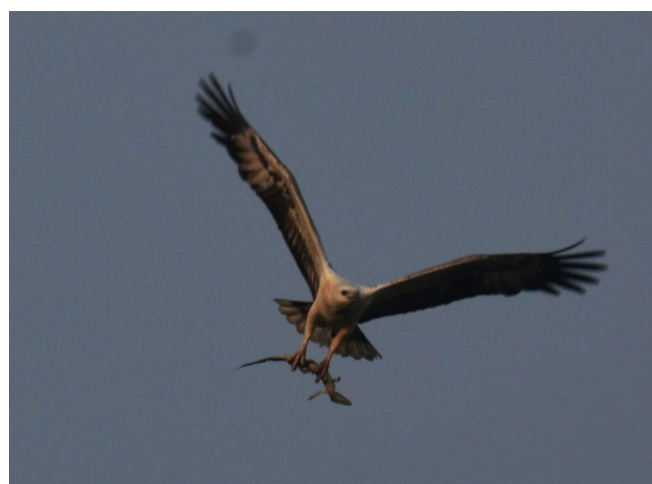


Figure 1. Predation of *Crocodylus porosus* hatchling by a White-bellied sea eagle. Photograph: Bijay Kumar Das.

BNP is also home to the largest *C. porosus* population (count of 1793 in 2023 census; Kar 2023) in India. During the annual census of *C. porosus* in the river systems of BNP, we usually observe one or a pair of *H. leucogaster* perching in tall trees (Fig. 2), or hovering and gliding down over the rivers and creeks.

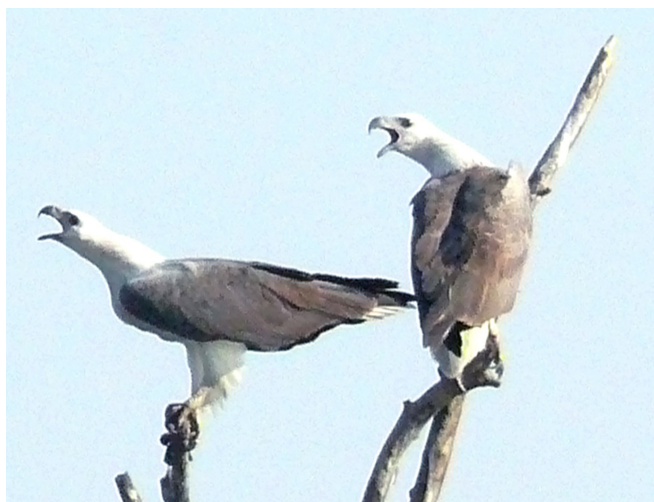


Figure 2. Pair of White-bellied sea eagles perching on dead tree branches in BNP. Photograph: Nimai-Bhakta.

On 2 January 2020, during the census in the main Bhitarkanika River close to Dangmal Creek (Kar 2020), we saw a White-bellied sea eagle hovering over the river. Suddenly it glided down close to the water and with a quick dive, went close to edge of the river bank and picked up a hatchling *C. porosus* with its talons. It then flew at speed to about 400 m away from the spot and perched on a tall Keruan tree (*Sonneratia apetala*), where it started eating the hatchling, even as it struggled to free itself. The crocodile was around 6 months old (August 2019 hatch) and about 35 cm long.

Since the implementation of the Crocodile Conservation and Research Project in BNP by the Odisha Forest Department in 1975, *C. porosus* nesting effort has increased significantly (from 3 in 1975 to 122 in 2022), as have hatchling counts (24 in 1975 to 569 in 2023; Kar 2023). The sea eagle population has also increased due to protection of nesting habitats. It is unknown how significant a predator sea eagles, and other birds of prey, are on young *C. porosus* in BNP. They no doubt contribute to the naturally high mortality of hatchling *C. porosus* in the first year of life.

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Literature Cited

- Behura, B.K. and Kar, S.K. (1981). A note on the egg predators of the saltwater crocodile, *Crocodylus porosus* Schneider in the Bhitarkanika Wildlife Sanctuary, Orissa. *Pranikee* 2: 25-28.
- Choudhury, B.C. and Bustard, H.R. (1980). Predation on natural nests of the Saltwater crocodile (*Crocodylus porosus* Schneider) on Northern Andaman island with notes on crocodile population. *Journal of the Bombay Natural History Society* 76: 311-323.
- Gopi, G.V. and Pandav, B. (2006). White-bellied sea-eagle *Haliaeetus leucogaster* preying on salt-water crocodile *Crocodylus porosus* hatchling. *India Birds* 2(6): 171.
- Kar, S.K. (2020). Results of annual census of Estuarine crocodiles in Bhitarkanika National Park, Odisha, India. *Crocodile Specialist Group Newsletter* 39(1):19-20.
- Kar, S.K. (2023). Results of annual census of Estuarine crocodiles (*Crocodylus porosus*) in the river systems in and outside Bhitarkanika National Park, Odisha, India. *Crocodile Specialist Group Newsletter* 42(1):12-14.
- Palei, N.C., Mishra, S.R. and Sahu, H.K. (2014). White-bellied Sea eagle (*Haliaeetus leucogaster*) in Bhitarkanika National Park, Odisha, India. *Cheetal* 51(1&2): 29-37.
- Singh, L.A.K. and Kar, S.K. (2021). Panira Raja Kumbhira (Crocodile: The King of Water). Singh, L.A.K. and Kar, S.K. and MDS Publication: Cuttack.
- Sudhakar Kar, Subhadra Nibas, Sampur, Bhubaneswar-751003, Odisha, India (kar.sudhakar@gmail.com).

Latin America & the Caribbean

Mexico

NON-FATAL HUMAN-CROCODILE INTERACTION WITH *CROCODYLUS MORELETII* IN ALTAMIRA, TAMAULIPAS. Human-crocodile interactions in Mexico represent a real problem in various parts of the country (García-Grajales and Buenrostro-Silva 2019), where crocodile populations cohabit with rural or urban human populations, causing competition for space and resources (Amarasinghe *et al.* 2015). Therefore, in 2018 the Mexican Federal Government presented the “Protocolo de Atención a Contingencias Humano-Crocodilíanos” (PACH-C; SEMARNAT 2018) to standardize management and minimize human-crocodile interactions. The state of Tamaulipas represents the northernmost distribution of the Swamp crocodile (*Crocodylus moreletii*), while the southern part (Tampico, Madero and Altamira) presents a wide lagoon system of more than 100,000 km² where *C. moreletii* occurs. This area represents a critical point for negative interactions with crocodiles, highlighting the fact that Tamaulipas ranks first in interactions with *C. moreletii* in the country (Cedillo-Leal, pers. comm.).

Therefore, in 2021 the Government of the municipality of Tampico activated the PACH-C and formed its first response “Grupo SOS Cocodrilo Tampico” (GSC-T), which pays attention to interactions with crocodiles in this municipality, and has a series of preventive strategies to minimize

interactions. The GSC-T is made up of municipality agencies (Ecology, Civil Protection, Fire Department, Animal Protection and Tourism), state dependencies (Tamaulipas Hunting and Sport Fishing Commission), federal agencies (PROFEPA) and health sector (Cruz Roja Mexicana and General Hospital). Currently, the neighboring municipalities of Altamira and Madero have not yet activated the PACH-C.

At 1900 h on 3 August 2022, an emergency (911) call was received for an interaction with a crocodile in Miramar Lagoon, located in the Nuevo Madero neighborhood of the Miramar sector in the city of Altamira, Tamaulipas (Fig. 1). The call was redirected to Cruz Roja Mexicana, a member of GSC-T, who through their staff activated the group's alert, even though the report was in a municipality neighboring Tampico. The interaction was classified as Grade 4 (unprovoked, non-fatal) according to PACH-C, caused by *C. moreletii*.



Figure 1. Site of Grade 4 (unprovoked, non-fatal) human-crocodile interaction with *Crocodylus moreletii* in Miramar Lagoon, Altamira, Tamaulipas, Mexico.

The victim was an 8-year-old girl named Fernanda “N”, who at the time of the interaction was in the company of her parents. The father was fishing with a cast net and the girl was playing at the edge of the water, when she was grabbed by the crocodile and dragged towards deeper water. The interview of the father followed PACH-C format, and revealed that:

- he had struggled with the crocodile for about 20 minutes to remove his daughter from its jaws.
- he estimated the crocodile was between 1.8 and 2.0 m long (Size 4; Sánchez-Herrera *et al.* 2011).
- he does not regularly fish (he is a shoemaker by trade), and was unaware of the existence of crocodiles in the area.

Although other negative interactions with crocodiles have occurred at this lagoon, there is no signage about the existence of crocodiles. Currently, the municipality of Altamira has a lack of adequate strategies to minimize risk, including lack of a first response team, identification of potential sites with interactions, adequate signage and training in contingency care.

Emergency medical personnel at the site provided pre-hospital care and transferred the girl to General Hospital “Dr. Carlos Canseco” in Tampico for her medical assessment. The medical report indicated that the girl presented bite injuries on the right arm and elbow (Fig. 2) and on the anterior and posterior thorax (Fig. 3), in addition to having swallowed a considerable amount of water. She remained in hospital for one week. Support and psychological follow-up were also provided to the victim and her parents.



Figure 2. Injuries sustained to upper right arm (left) and elbow (right).



Figure 3. Injuries on abdomen.

Having an active and trained “SOS Cocodrilo” first responder group can be the difference between saving a life or not. Even simple preventive strategies such as appropriate signage can reduce the risk of negative interactions with crocodiles.

Personnel of the emergency department of the General Hospital “Dr. Carlos Canseco” are also active members of the GSC-T. Medical personnel were prepared from the moment the alert from the Grupo SOS was activated, maximizing the attention of the victim to only the time it takes to transport her to the hospital. The communication and direct link between both health institutions to attend to victims of crocodile interactions has been fundamental to minimizing time in hospital and health risk to victims. This communication and coordination is something that did not occur before. It demonstrates that having a critical path in place across the board (operational, administrative and health) is essential to addressing negative human-crocodile interactions.

Currently, a comprehensive project has been proposed to activate the PACH-C in the municipality of Altamira and form the first response group, as well as preventive and reactive actions in the face of negative human-crocodile interactions that occur in this municipality.

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We thank members of Grupo SOS Cocodrilo Tampico, especially staff of Cruz Roja Mexicana and Hospital General “Dr. Carlos Canseco” for their prompt and effective response to this event. In addition, we thank the father of the victim for providing accurate and truthful information on the case.

Literature Cited

Amarasinghe, A.A., Madawala, M.B., Karunarathna, D.M.S., Manolis, C., De Silva, A. and Sommerlad, R. (2015). Human- crocodile conflict and conservation implications of saltwater crocodiles *Crocodylus porosus* (Reptilia: Crocodylia: Crocodylidae) in Sri Lanka. *Journal of Threatened Taxa* 7: 7111-7130.

García-Grajales, J. and Buenrostro-Silva, A. (2019). Assessment of human-crocodile conflict in Mexico: Patterns, trends and hotspots areas. *Marine and Freshwater Research* 70: 708-720.

Sánchez Herrera, O., López Segurajáuregui, G., García Naranjo Ortiz de la Huerta, A. and Benítez Díaz, H. (2011). Programa de Monitoreo del Cocodrilo de Pantano (*Crocodylus moreletii*) México-Belice-Guatemala. México. Comisión Nacional para el Conocimiento y Uso de la Biodiversidad: México. 270 pp.

SEMARNAT (2018). Protocolo de Atención a Contingencias Humano-Crocodilianos. Componente de manejo de Poblaciones del Programa de Acción para la Conservación de Especies (PACE): Crocodylia (*Crocodylus acutus*, *Crocodylus moreletii*, *Caiman crocodilus chiapasius*). SEMARNAT/CONANP: México.

Cesar N. Cedillo-Leal¹, Gabriel Cruz-Morales² and Gabriel Barrios-Quiroz³: ¹*Centro de Estudios en Desarrollo Sustentable y Aprovechamiento de la Vida Silvestre, Av. Héroe de Nacozari #480, Campus VI de Investigaciones, Universidad Autónoma de Campeche, Campeche, México CP 24095 (mvzleal1@gmail.com);* ²*Cooperativa Servicios Ecoturísticos de La Ventanilla S.C. de R.L. de C.V., La Ventanilla, Santa María Tonameca, Oaxaca, México (café.cientifico.2016@gmail.com);* ³*Ecología y Conservación Dharma A.C., Carretera Yauatepec-Tepoztlán Km 7.5, Barrio de Santiago Tepetlapa, Tepoztlán Morelos, Mexico CP 62520 (barriosg910@gmail.com).*

Belize

CROCODILE TALK: STRUCTURAL ANALYSIS OF AMERICAN AND MORELET’S CROCODILE VOCALIZATIONS IN BELIZE. Out of the extant reptilians, crocodilians are the most vocal (Vergne *et al.* 2009), using vocalizations for social interactions such as courting and territorial defense (Vergne *et al.* 2012), as well as distress or threat calls (Boucher *et al.* 2020). The two species of crocodiles occurring in Belize, the American crocodile (*Crocodylus*

acutus) and Morelet’s crocodile (*C. moreletii*), have been hypothesized to interbreed based on genetic evidence and morphological traits of both species being exhibited in individuals (Ray *et al.* 2004). Although hybridization is a naturally occurring phenomenon, anthropogenic factors have escalated the rate at which hybridization occurs. Interbreeding is more prevalent now where species were separated in the past, as physical barriers, such as densely forested areas, have been removed. Hybridization is a major threat to *C. moreletii*, as it could eventually lead to the decline of the pure-bred populations and their displacement by hybrids (González-Trujillo *et al.* 2012).

With an increase in the use of technology in biology, new surveying methods are being implemented on a global scale. Acoustic monitoring uses sounds produced by a species to detect its presence by placing recorders in the field for an extended period of time. The recordings are then analyzed for any known sounds, such as specific calls made by an animal. There are many benefits to using Passive Acoustic Monitoring (PAM) for conservation, to estimate species presence and abundance, population density, and different community compositions, as well as monitoring spatial and temporal trends in species (Browning *et al.* 2017).

Some research on vocalization in *C. acutus* has been carried out (Boucher *et al.* 2020), but there is little known about the call structure of *C. moreletii*. This research aimed to provide a better understanding of vocalization structures in *C. acutus*, *C. moreletii* and hybrids of the two species, that could be used to: 1) understand differences in vocalizations between these species and hybrids; and, 2) possibly implement PAM distribution surveys in future research. In addition to looking at differences between species, differences between individuals were also examined.

Methodology

The study area was on the eastern coast of Belize, at five different sites (Fig. 1). Crocodiles were captured from a boat during surveys in August 2022. Ten (10) surveys were carried out, with some areas having multiple surveys (eg 3 surveys in Belize City).

Capture surveys were conducted following safe capture and examination practices developed by Sánchez Herrera *et al.* (2011). Spotlight surveys were carried out from a motorboat, and began 15-30 minutes after sunset. Crocodiles were spotted by shining a spotlight and looking for a red eyeshine. When a crocodile was spotted, it was captured by hand or with catchpole snares depending on size, and brought on board the boat or onto land if an adult.

Vocalizations that occurred during capture and restraint were recorded for approximately 1-3 minutes using the AVR X application on an iPhone 11 with the settings set to; WAV file format, High encode quality, sample rate of 48,000 Hz, bitrate at 320 kbps and a Mono channel. The microphone was held approximately 1-2 m from larger sub-adult and adult crocodiles for safety, but smaller sub-adults, juveniles and



Figure 1. Locations (stars) where surveys were carried out.

hatchlings were handheld, and the microphone was placed about 0.5 m away (Boucher *et al.* 2020).

Morphometric data (head length, snout length, pre-orbital length, pre-orbital width, cranial width, maxillary width, premaxillary width, total length, snout-vent length, tail width, right hind foot length) and sex were recorded. Crocodiles were also categorized on the basis of size [hatchling (<50 cm), juvenile (51-120 cm for *C. acutus*, 51-100 cm for *C. moreletii*), sub-adult (121-180 cm for *C. acutus*, 101-150 cm for *C. moreletii*), adult (181-240 cm for *C. acutus*, 151-200 cm for *C. moreletii*)] and possible species identification. If traits of both *C. acutus* and *C. moreletii* were present within one individual, it would be categorized as a hybrid. Photographs of nuchal scute and tail patterns were taken for possible future examination. We also examined individuals for health and presence of external parasites.

The recordings were analyzed, and low-quality calls were filtered out and excluded from analyses. These low-quality files included any with heavy background sound interference and talking or movement noise. This was done by an aural and visual inspection of the spectrograms in RavenPro. To standardize analysis, only 7 calls were selected from each individual. The first usable 7 calls with clear spectrograms that contained little to no interference from undesired sounds in the file were selected for analysis.

With RavenPro, the calls were isolated and the fundamental frequencies of the calls were analyzed in 0.005 second

segments to measure beginning, end, first quartile, and max frequencies, as well as total duration and duration of the first quartile. The slope of the first quartile [Slope 1, calculated by $(F_{1/4} - F_{\max})/D_{1/4}$] was determined, where $F_{1/4}$ is the frequency at the first quartile, F_{\max} is the maximum frequency and $D_{1/4}$ is the duration of the first quartile. The slope of the remaining three quartiles [Slope 2, calculated by $(F_{\text{end}} - F_{1/4})/(DT - D_{1/4})$] was also determined, where F_{end} is the end frequency, and DT is the total duration (Boucher *et al.* 2020).

For each species and size class, averages and standard deviations were calculated for Slopes 1 and 2, as well as total duration, first quartile duration, maximum frequency and first quartile frequency. Individual crocodile vocalizations were also compared within species and size class.

Results

Vocalizations were recorded from 21 crocodiles (ranging in size from 32.4 to 110.7 cm TL) across all surveys, from which data for 7 crocodiles were considered suitable for analysis; two juvenile and one sub-adult *C. moreletii*, and two hatchling and two juvenile *C. acutus*. It was unfortunate that only one third of the crocodiles could be used due to low quality recordings.

Notwithstanding the low sample sizes involved, the following were concluded:

- The sub-adult *C. moreletii* had a lower total duration than the juvenile *C. acutus* group (0.13 s vs 0.21 s).
- Slope 1 for the juvenile *C. moreletii* group was more negative than that of the juvenile *C. acutus* group.
- Slope 2 for the sub-adult *C. moreletii* was more negative than that of the hatchling and juvenile *C. acutus* groups.
- Visual comparisons of the data reveal no clear distinction between age class or species, however, there were considerable differences between individual crocodiles.

For the k-means clustering analysis, the optimal number of clusters was determined to be two, which allowed for all 7 points to be grouped into a cluster. Cluster 1 was more widespread, whereas Cluster 2 was more compact (Fig. 2). Both clusters contained individuals of both species and contained different size classes. The average size of crocodiles in Cluster 1 was similar to the average size for crocodiles in Cluster 2 (66.27 vs 71.28 cm). There was no clear pattern found in species or size class.

To determine if there is at least one statistically significant difference between individual crocodiles, an ANOVA test (with Welch's correction), using a confidence interval of 95%, was carried out. There was a statistical difference ($p < 0.05$) between all vocalization variables.

However, although there was a difference between the variables, the ANOVA test has certain conditions that are expected to be met, including that data are random/independent and normally distributed, and that there is homogeneity in the variance. Welch's correction was used to eliminate the issue

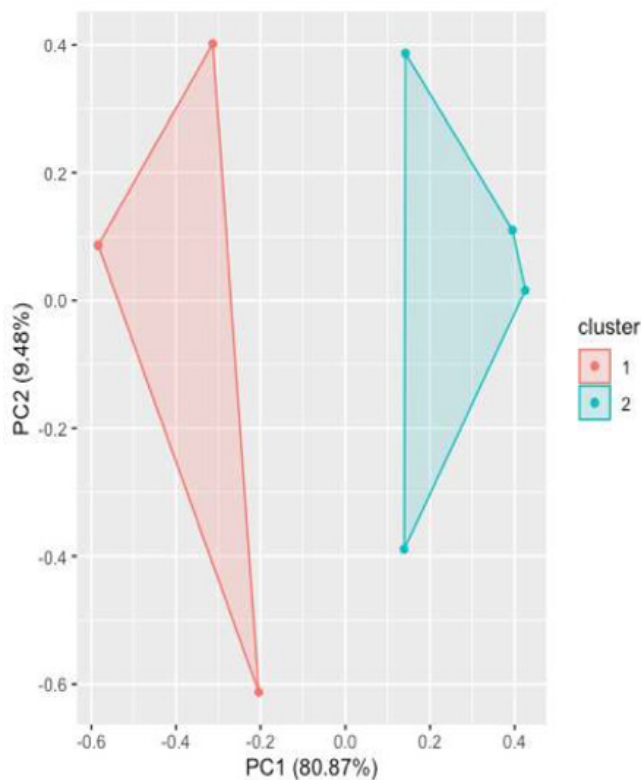


Figure 2. Results of K-means clustering analysis, with two clusters (1 and 2). Percentages are the proportion of how the variance in the data is explained by one of the principal components.

with unequal variances, however the Shapiro-Wilk test was used to determine whether the data were normally distributed. The only variables that had no evidence for non-normality were Slope 1 and Total Duration, meaning that the p-values calculated for the other variables cannot be trusted because the data did not meet the assumptions for the ANOVA test.

Slope 1 and Total Duration were further subjected to a Games-Howell Post-Hoc test to determine where the statistical differences were found after running the ANOVA test. This test uses multiple comparisons that adjust the p-value to lower the risk of a false positive result. There is a 95% confidence interval, so the difference is statistically significant if the p-value is less than 0.05.

The post-hoc test for Total Duration indicated there were no statistical differences between:

- Morelet's Juvenile 1 and Morelet's Sub-adult or American Hatchling 2
- Morelet's Juvenile 2 and American Juvenile 1 or American Hatchling 1
- Morelet's Sub-adult and American Hatchling 2
- American Hatchling 1 and American Juvenile 2

The post-hoc test on Slope 1 indicated there were no statistical differences between:

- Morelet's Juvenile 2 and Morelet's Sub-adult or American Juvenile 1 or American Hatchling 2

- Morelet's Sub-adult and American Juvenile 1 or American Hatchling 2
- American Juvenile 1 and American Hatchling 2
- American Hatchling 1 and American Juvenile 2

Conclusions

Call structures in the 7 crocodiles analyzed varied between individuals. There was no clear pattern found between size class or species. However, this may have been due to a small sample size. It is possible that an expansion of the sample size may reveal patterns between size/age class, or species. Unfortunately, the hybrid crocodiles that were captured were not included in analyses due to low quality recordings.

When visually inspecting the spectrograms of all of 21 individuals, there were some observations that stood out. The slope pattern of the individuals differed, where some had increases within the slope (visually looks like a hill), others had only negative slopes. Those vocalizations with a portion having a positive slope were found in both species and sometimes occurred multiple times within the same individual.

There was also one individual whose call was not similar to any of the other individuals in that it had a long section with an increasing slope before the "standard" downward slope. The embellishment of the vocalization had a majority positive slope, which is different from the standard vocalizations.

It is clear that individuals can exhibit very different vocalization structures. There was a lot of variation between individuals within the same size class and species. For example, the two *C. acutus* hatchlings had no overlap within their values for five out of the seven variables visualized in box and whiskers plots. In addition to a visual comparison using boxplots, there were statistically different values in the variables analyzed with the Games-Howell post-hoc test. This suggests that these vocalizations are distinct from one another, although they are of the same species and size/age class.

It was previously expected that vocalizations made by crocodiles would be stereotypical and have little variation between individuals because they are reptiles, which are generally considered to have simple social and communication systems. However, these data show that there is great variation between individuals, so these vocalizations are more complex than previously thought.

Although this research is limited regarding species and size/age class, it could still be helpful when implementing PAM for conservation management purposes. It is known that American crocodiles inhabit areas with salt water frequently, and some call types are specific to certain age classes, like mating calls, so PAM could be used for population monitoring.

The study would have benefitted from being continued over a longer period of time, with better recording equipment and a larger sample size of species and size class, in order

to make analysis more robust. In addition, the calls analyzed during this study were specifically distress calls. It would be beneficial for this study to be replicated and incorporate courting calls as well.

Literature Cited

- Boucher, M., Tellez, M. and Anderson, J.T. (2020). Differences in distress: Variance and production of American crocodile (*Crocodylus acutus*) distress calls in Belize. *Ecology and Evolution* 10(18): 9624-9634.
- Browning, E., Gibb, R., Glover-Kapfer, P. and Jones, K.E. (2017). *Passive Acoustic Monitoring in Ecology and Conservation*. WWF Conservation Technology Series 1(2). WWF-UK: Woking, United Kingdom.
- González-Trujillo, R., Rodriguez, D., González-Romero, A., Forstner, M.R.J., Densmore III, L.D. and Reynoso, V.H. (2012). Testing for hybridization and assessing genetic diversity in Morelet's crocodile (*Crocodylus moreletii*) populations from central Veracruz. *Conservation Genetics* 13(6): 1677-1683.
- Marques, T.A., Thomas, L., Martin, S.W., Mellinger, D. K., Ward, J.A., Moretti, D.J., Harris, D. and Tyack, P.L. (2013). Estimating animal population density using passive acoustics. *Biological Reviews* 88(2): 287-309.
- Ray, D.A., Dever, J.A., Platt, S.G., Rainwater, T.R., Finger, A.G., McMurtry, S.T., Batzer, M.A., Barr, B., Stafford, P.J., McKnight, J. and Densmore, L.D. (2004). Low levels of nucleotide diversity in *Crocodylus moreletii* and evidence of hybridization with *C. acutus*. *Conservation Genetics* 5(4): 449-462.
- R Core Team (2021). *R: A Language and Environment for statistical computing*. R Foundation for Statistical Computing: Vienna, Austria.
- Sánchez Herrera, O., López Segurajáuregui, G., García Naranjo Ortiz de la Huerta, A. and Benítez Díaz, H. (Eds.) (2011). *Programa del monitoreo del cocodrilo de pantano (Crocodylus moreletii) México-Belice-Guatemala*. Comisión Nacional para el Conocimiento y Uso de la Biodiversidad: México.
- Vergne, A.L., Pritz, M.B. and Mathevon, N. (2009). Acoustic communication in crocodilians: From behaviour to brain. *Biological Reviews* 84(3): 391-411.
- Vergne, A.L., Aubin, T., Martin, S. and Mathevon, N. (2012). Acoustic communication in crocodilians: Information encoding and species specificity of juvenile calls. *Animal Cognition* 15(6): 1095-1109.
- Helena Wood-Barron (*Sarasota, FL, USA*) and Athena Rycyk (*New College of Florida, Sarasota, FL, USA*).



Recent Publications

Ghorai, S.K.K., Bar, S., Singh, S., Das, A.K., Justin, J. and Ghosh, D. (2023). Forest wildlife dependencies and conflicts in the Indian Sundarbans. Available at SSRN: <https://ssrn.com/abstract=4500123> or <http://dx.doi.org/10.2139/ssrn.4500123>.

Abstract: The Sundarbans act as home to diverse group of wildlife and provide livelihoods for millions of people present in Sundarbans. The wildlife and human population closely associated with each other in this vulnerable ecosystem that is marked by the complex ecological interactions with dependencies and conflicts. This article provides brief overview about the dependencies of local people of Sundarbans and the conflicts associated with it. The local communities are highly dependent on the natural resources of Sundarbans for their survival and economic well being. Local people involve in various type of activities like fishing, crab collection, honey collection, fire wood collection, etc. The unique biodiversity of Sundarbans attract tourist from different part of the Globe and plays an important role for the growth of tourism industry in Sundarbans. The human activities are the major causes for the conflicts with wildlife in this area. Especially the major focus of conflict is the Royal Bengal Tiger and crocodile being a potential threat to human life. The invasion of human settlements into the natural habitats and habitat degradation lead to the imbalance of ecosystem causing conflicts with wildlife. The dependencies and conflicts between human and wildlife need a balanced approach for the conservation and development. After knowing the crucial role of Sundarbans in maintaining the livelihood of local people, it is essential to hold the ecological integrity through sustainable co-existence.

Karlsson, J. (2023). *The Functional Anatomy of the Crocodilian Heart*. BSc thesis, Linköping University, Linköping, Sweden.

Abstract: Crocodiles are ectothermic, intermittent breathing reptiles with low metabolic rates. Additionally, they are diving animals that can stay submerged for long periods, which poses special demands on their cardiovascular system. The crocodilian heart is four-chambered with completely separated ventricles, making it unique among other reptiles. It has special anatomical structures that give it the capability to shunt blood away from the lungs, which results in mixing of deoxygenated and oxygenated blood. The purpose of this study was to morphologically describe the heart and review its functions and the significance of its circulatory patterns. Dissection of two crocodilian hearts was performed for morphological characterization of the heart, including the special features that contribute to the shunting: the left aorta, the foramen of Panizza and the cog-teeth-like valves. Obstruction of the pulmonary outflow tract by the cog-teeth-like valves decreases pulmonary blood flow and generates an increased right ventricular pressure, diverting venous blood into the 'extra' left aorta and the systemic circulation. Thus, during shunting conditions, venous blood from the left aorta and arterial blood from the right aorta is mixed. The functional significance of this shunting pattern has been extensively discussed and several hypotheses have been proposed. A recent study showed that the absence of the right-to-left shunt does not affect the diving physiology of crocodiles negatively, but it did result in cardiac hypertrophy, indicating that the shunt might have a significance for the circulation and physiology of extant crocodiles.

Soukup, M. (2023). Daggers of New Guinea: distribution, styles and functions. *Anthropologia integra* 14(1) (<https://doi.org/10.5817/AI2023-1-7>).

Abstract: This review is focused on bone daggers, the objects, which were widespread during colonial era, as well as in earlier times in New Guinea. Production and use of these daggers has decreased due to modernization occurring among inhabitants of the island. These, indeed specific tools, were manufactured from bones gained from cassowaries, crocodiles and humans. The description of the main types of bones daggers and knives linked to particular areas of New Guinea are examined in the review. Article also follows its aesthetic values, functionalities, along with its social importance and cultural symbolism.

Venkatesan, S.S., Neelam, P., Satyakeerthy, T.R., Sunil, J. and Binoj, K.K. (2023). Pathway of poultry waste and its environmental repercussions in South Andaman, India: A discussion. *Indian Journal of Natural Sciences* 14(77): 54573-54579.

Abstract: Protein demands of the mammoth global population are cratered by poultry meat when compared to other meat thus, generating massive organic waste. The objective of the present study is 1) to understand the pathway of poultry and its related waste, and 2) the implications due to the use of poultry and its related waste on the health of the environment and humans as well in south Andaman. Frequent eutrophication in the coastal waters of the study area was due to the presence of nitrate contents from the land runoff. Further, human encounters with saltwater crocodiles due to the use of poultry offals as feed to freshwater fishes. Also, eutrophication in the freshwater aqua ponds resulting in reduced dissolved oxygen levels increased pH and resulting in 80% mortality of the freshwater fishes. It is hereby concluded that an immediate ban on the use of poultry litter and its offals is the need of the hour to conserve the pristine environment of the study area.

Ojeda Adame, R.A., Chávez Dagostino, R.M., Gerritsen, P.R.W., Aguilar Olguín, S. and Íñiguez Dávalos, L.I. (2023). State of the art on the conflictive relationship of the human with the crocodile. *Teoría y Praxis* 31 (Edición Especial) (doi: [10.22403/UQROOMX/TyP31](https://doi.org/10.22403/UQROOMX/TyP31)).

Resumen: El resultado de la interacción entre humanos y fauna produce escenarios donde la conservación y el desarrollo local sustentable se comprometen. Aunque es un tema relevante por sus implicaciones, no existen estudios que hayan sistematizado el conocimiento generado con respecto a las especies involucradas y las características del conflicto. Esta investigación, a través de una revisión sistemática de bases de datos y un análisis narrativo de contenido, identifica y analiza el conflicto humano-cocodrilo a nivel mundial en 28 artículos, con base en el origen y tendencia de las investigaciones, especies involucradas y tipo de interacción. La relación conflictiva es explicada a través de aspectos biológicos como la reproducción o dieta del saurio, así como de su crecimiento poblacional o demográfico, pero también de factores ambientales como el nivel de agua o temperatura, se identificaron las repercusiones económicas y para la conservación de las especies asociadas a este conflicto. Dominan los estudios centrados en ataques a humanos, en el continente americano y para la especie *Crocodylus acutus*. Los efectos del cocodrilo fueron directos (ataque a humanos) e indirectos (daños a la pesca, agricultura, ganadería, mascotas). El conflicto de intereses entre grupos sociales, así como los aspectos ligados a cultura, percepción, religión u otras cualidades sociales, fueron poco abordados por los artículos analizados.

Abstract: Human-wildlife interaction results in scenarios where conservation and sustainable local development are compromised. Although it is a relevant topic because of its implications, there are no studies that have systematized the knowledge generated regarding the species involved and the characteristics of the conflict. This research, through a systematic review of databases and a narrative content analysis, identifies and analyzes the human-crocodile conflict worldwide in 28 articles, based on the origin and trend of the research, species involved, and type of interaction. The

conflictive relationship is explained through biological aspects such as the reproduction or diet of the saurian, as well as its population growth or demographic growth, but also environmental factors such as water level or temperature, economic and conservation repercussions of the species associated with this conflict were identified. Studies focused mainly on attacks on humans, in the American continent, and the *Crocodylus acutus* species dominated the studies. The effects of crocodiles were direct (attacks on humans) and indirect (damage to fisheries, agriculture, livestock, and pets). The articles analyzed hardly address the conflict of interests between social groups and aspects linked to culture, perception, religion, or other social qualities.

Wen, Y., Zhan, J., Li, C., Li, P., Wang, C., Wu, J., Xu, Y., Zhang, Y., Zhou, Y., Li, E., Nie, N. and Wu, X. (2023). G-protein couple receptor (GPER1) plays an important role during ovarian folliculogenesis and early development of the Chinese Alligator. *Animal Reproduction Science* 255 (<https://doi.org/10.1016/j.anireprosci.2023.107295>).

Abstract: The critical role of the G protein-coupled receptor 1 (GPER1), a member of the seven-transmembrane G protein-coupled receptor family, in the functional regulation of oocytes accumulated abundant theories in the early research on model animals. However, the full-length cDNA encoding GPER1 and its role in the folliculogenesis has not been illustrated in crocodilians. 0.5, 3, and 12 months old *Alligator sinensis* cDNA samples were used to clone the full-length cDNA encoding GPER1. Immunolocalization and quantitative analysis were performed using Immunofluorescence technique, RT-PCR and Western blot. Simultaneously, studies on GPER1's promoter deletion and cis-acting transcriptional regulation mechanism were conducted. Immunolocalization staining for the germline marker DDX4 and GPER1 demonstrated that DDX4-positive oocytes were clustered tightly together within the nests, whereas scarcely any detectable GPER1 was present in the oocytes nest in Stage I. After that, occasionally GPER1-positive immunosignal was observed in oocytes and somatic cells additional with the primordial follicles, and it was mainly located at the granulosa cells or thecal cells within the early PFs in the Stage III. The single mutation of the putative SP1 motif, double mutating of Ets/SP1 and SP1/CRE binding sites all depressed promoter activities. This result will help to investigate the role of GPER1 in the early folliculogenesis of *A. sinensis*.

Wang, J., Su, B., Al-Armanazi, J., Wise, A.L., Shang, M., Bern, L., Li, S., Xing, D., Johnson, A., Wang, W., Hettiarachchi, D.U., Coogan, M., Bruce, T.J. and Dunham, R.A. (2023). Integration of alligator cathelicidin gene via two CRISPR/Cas9-assisted systems enhances bacterial resistance in blue catfish, *Ictalurus furcatus*. *Aquaculture* (<https://doi.org/10.1016/j.aquaculture.2023.739860>).

Abstract: CRISPR/Cas9-mediated genome editing has paved new avenues for improving production-valued traits in aquaculture by knocking out or disrupting functional genes. However, utilizing CRISPR/Cas9-based knock-in (KI) of exogenous genes can expedite genetic improvement of traits such as disease resistance, which remains problematic in farmed fish. In this study, we successfully generated transgenic blue catfish (*Ictalurus furcatus*) of primarily Rio Grande strain ancestry with site-specific KI of the alligator (*Alligator sinensis*) cathelicidin (As-Cath) gene into the luteinizing hormone (lh) locus via two CRISPR/Cas9-mediated KI systems, assisted by the linear double-stranded DNA (dsDNA) and double-cut plasmid, respectively. High integration rates were observed with linear dsDNA (16.67%, [13/78]) and double-cut plasmid strategies (24.53%, [26/106]). In addition, the on-target KI efficiency of the double-cut plasmid strategy (16.04%, [17/106]) was 1.67 times higher than that of the linear dsDNA strategy (10.26%, [8/78]) based on the odds ratio. The relative expression of the As-Cath transgene of P1 founders was detected in nine tissues, dominated by the kidney, skin, and muscle (14.30-, 7.71- and 6.92-fold change, $P < 0.05$). Moreover, the As-Cath transgenic blue catfish showed

a higher cumulative survival rate than that of wild-type controls (80% vs. 30%, $P < 0.05$) following *Flavobacterium cova* infection. Survival during culture supports the challenge data as survival of As-Cath transgenic individuals was 97.1% while that of pooled non-transgenic individuals was observed to be less 87.0% ($P = 0.15$). The growth rates and external morphology of the transgenic and wild-type siblings were not different ($P > 0.05$), indicating no pleiotropic effects of the As-Cath transgene integration at the lh locus in the P1 founders for this trait. Taken together, our findings demonstrate that CRISPR/Cas9-assisted KI of an antimicrobial peptide gene can be achieved in blue catfish with high integration efficiency, and As-Cath transgenic blue catfish have improved disease resistance, which is a promising strategy for disease reduction in aquaculture.

Cordero Gil, T. de los A., Amavet, P.S., Marelli, B.E. and Siroski, P.A. (2023). Evidence of venom factor-like in crocodilians. *Organisms Diversity & Evolution* (<https://doi.org/10.1007/s13127-023-00617-8>).

Abstract: The cobra venom factor (CVF) is an unusual non-toxic complement system-activating protein reported in the venom of many family Elapidae snakes, and it is closely related to C3 complement. The archosaurs, including crocodilians, were traditionally considered a completely non-venomous group of animals; however, the identification of some related sequences similar to CVF proteins in the crocodilian genome may trigger important discussions and manage interesting hypotheses. The aim of this work was to identify VF-like protein in *Caiman latirostris* DNA samples. The results demonstrate the presence of VF-like in *C. latirostris* and showed a strong homology of VF-like and C3 complement, indicating a probable paralogy between both proteins in crocodilians. Also, these findings provide some potential explanations to justify presence of VF-like protein in crocodilians: one is based on the horizontal transfer of a transposable element from a virus as a vector, and another proposes the horizontal gene transfer by the predator-prey interaction between crocodilians and snakes. Our results are in accordance with investigations that propose the presence of snakes' venom components in non-venomous reptiles. However, more research will be needed to determine if VF-like in crocodilians has a similar function to CVF.

Palmer, J.L., Nieto-Claudín, A., Sosa Rodriguez, G., Perez Fleitas, E., Augustine, L. and Deem, S.L. (2023). Hematology and blood chemistry values in Cuban crocodiles (*Crocodylus rhombifer*) housed at the Zapata Swamp Crocodile Farm, Cuba. *Journal of Zoo and Wildlife Medicine* 54(2): 301-309.

Abstract: We report hematology and biochemistry reference intervals (RI) for the critically endangered Cuban crocodile (*Crocodylus rhombifer*). In November 2019, we sampled 43 adult crocodiles (6 male, 37 female) under human care at the Zapata Swamp Crocodile Farm in Matanzas, Cuba. These crocodiles are part of a breeding program for the species registered by the Convention on International Trade in Endangered Species (CITES). Visual health evaluations were performed immediately after manual restraint, and blood was collected from the postoccipital sinus. We performed packed cell volume (PCV), total solids (TS), complete blood counts (CBC), and biochemistry profiles for each crocodile on the day of sampling. Mean PCV ($n = 42$) was $21.1 \pm 5.0\%$ and TS ($n = 42$) 7.3 ± 1.2 mg/dl, respectively. Absolute white blood cell (WBC) ($n = 40$) was $9.6 \pm 5.7 \times 10^9/L$. Similar to other crocodilian species, the dominant leukocyte was lymphocytes ($70.7 \pm 10.4\%$), followed by heterophils ($18.7 \pm 9.7\%$). Two of the crocodiles had a high heterophil:lymphocyte ratio (0.87 and 0.74), although on visual exam they were both considered healthy. The range of creatine kinase was 41-1482 U/L, and the higher values may be a reflection of muscle exertion at time of handling. Limitations to the study included skewed sex ratios and high lipemia and hemolysis in most samples collected. These are the first reference intervals reported for this species, including the first descriptions of WBC morphology.

These data are valuable for the management of animals at the Zapata Swamp Crocodile Farm, for comparison with free-living Cuban crocodiles in Cuba, and for comparison with those managed under human care outside of Cuba.

López-Román, A., Jiménez-Herranz, E., Calderón-Montero, J., Ramos-Álvarez, J.J. and Gómez-Lucas, R. (2023). Cardiovascular response to exercise in vertebrates: A review. Preprints ([doi: 10.20944/preprints202307.0500.v1](https://doi.org/10.20944/preprints202307.0500.v1)).

Abstract: Exercise is the greatest stress for the cardiovascular system, not only for the human being but for the rest of vertebrates. For this reason, the cardiovascular response cannot be considered as only one “anthropocentric” meaning. The adjustment of cardiac output to exercise in the five large groups of vertebrates is highly variable. The response of the heart rate and the stroke volume as the main two basic factors that determine the increase in cardiac output is also highly variable. The difference in the range of heart rate is difficult to determine in many vertebrates, both at rest and maximum effort. The increase in stroke volume also differs among vertebrates. For example, while rainbow trout and leopard increase their stroke volume by increasing final diastolic volume (Frank Starling's law), humans do so at the expense of both increasing final diastolic volume and reducing final stroke volume (contractility). The variation in arterial pressure that occurs during exercise also differs considerably among vertebrates. Large differences in cardiovascular response between different vertebrates could be related to their habitat or living environment. This review aims to analyze the cardiovascular response to exercise, as the most common stress condition in vertebrates.

Chandamala, H.J. and Paul, N. (2023). Analysis of hatching success and population of Gharial (*Gavialis gangeticus*) in Lucknow region (in captivity). *Journal of Global Biosciences* 12(5): 9835-9846.

Abstract: Gharial (*Gavialis gangeticus*), a biological treasure of the Indian subcontinent, is now restricted to a small number of India and Nepal's major river systems. The Gharial species is listed as Critically Endangered on the IUCN 2007 Red List, despite the coordinated conservation efforts made by Nepal and India since the middle of the twentieth century. Gharial census was held in January and February 2008 by the Department of National Parks and Wildlife Conservation (DNPWC) and World Wildlife Fund (WWF) Nepal because they were aware that estimating the population's status, structure, and geographic distribution is an essential step in any conservation plan involving mega herpetofauna. 70 of the Gharials that were recorded during the census were based on direct sighting, while 11 were based on indirect observations. Flooding and dam construction, the destruction of habitat, and a decline in the quantity and quality of food all contributed to the decline in the Gharial population. The quantity and quality of the fish that Gharial relies on for his primary diet were negatively impacted by overfishing, the use of gill nets, and river poisoning. Because of the sudden decline in the gharial population, of the Indian Government in 1975, the Indian Crocodile Conservation Project was set up initially in Odisha's Satkosia Gorge Sanctuary. In 1976, two breeding centers were established in Uttar Pradesh, one at the Kukrail Reserve Forest and the other at Katarniaghat Wildlife Sanctuary, with proper facilities to hatch and raise up to 800 gharials each year for release in the rivers. These included the egg collection program, and this study focuses on the number of eggs collected and successfully hatched from the year 2018-2022. Mainly focusing on these years because of the interception of covid. A major change was seen in the number of collections of eggs in 2021, because nature was undisturbed by humans.

Du, W-G., Li, S-R., Sun, B-J. and Shine, R. (2023). Can nesting behaviour allow reptiles to adapt to climate change? *Philosophical Reactions of the Zoological Society B* 378(1884) (<https://doi.org/10.1093/zool/378.1884>).

Abstract: A range of abiotic parameters within a reptile nest influence the viability and attributes (including sex, behaviour and body size) of hatchlings that emerge from that nest. As a result of that sensitivity, a reproducing female can manipulate the phenotypic attributes of her offspring by laying her eggs at times and in places that provide specific conditions. Nesting reptiles shift their behaviour in terms of timing of oviposition, nest location and depth of eggs beneath the soil surface across spatial and temporal gradients. Those maternal manipulations affect mean values and variances of both temperature and soil moisture, and may modify the vulnerability of embryos to threats such as predation and parasitism. By altering thermal and hydric conditions in reptile nests, climate change has the potential to dramatically modify the developmental trajectories and survival rates of embryos, and the phenotypes of hatchlings. Reproducing females buffer such effects by modifying the timing, location and structure of nests in ways that enhance offspring viability. Nonetheless, our understanding of nesting behaviours in response to climate change remains limited in reptiles. Priority topics for future studies include documenting climate-induced changes in the nest environment, the degree to which maternal behavioural shifts can mitigate climate-related deleterious impacts on offspring development, and ecological and evolutionary consequences of maternal nesting responses to climate change.

Hoog, M.E. (2023). The Effect of Genetic Relatedness on Mate Selection and Spatial Distribution in the American Alligator, *Alligator mississippiensis*. MSc thesis, Georgia Southern University, xxxxx, USA (Electronic Theses and Dissertations. 2619. <https://digitalcommons.georgiasouthern.edu/etd/2619>).

Abstract: To date, most genetic studies on the American alligator (*Alligator mississippiensis*) have focused on population genetics and multiple paternity. There have not been any studies looking at how relatedness affects alligator behavior and movement. This study focused on three main questions: 1) what is the genetic diversity among alligators in this location? 2) can parentage be accurately defined among parents and offspring? and 3) how does individual relatedness affect their spatial distribution? We examined the relatedness of 174 unique individuals from the Okefenokee Swamp Park, in South Georgia, USA. In addition, we placed Telonics® satellite tags on 10 adult alligators and created home ranges for these animals. We extracted DNA from tissue, bone, and egg samples, screened multiple microsatellites via PCR, and characterized each individual's genotype. Mean Pairwise Relatedness (MPR) was used to determine the upper and lower 95% confidence limits to describe the expected random deviations of MPR if random mating occurred among sites. The data were categorized into six groups based on the sex and age classes of the alligators. The MPR was calculated among individuals with known GPS capture locations and tracking movement data to examine the effect of relatedness on spatial distribution. By including the GPS locations, it was possible to test if animals with overlapping, or disjunct home ranges differed in genetic relatedness. Observational field data and MPR were also used to test relatedness among all sampled alligators. Since alligators had known age classes and sex, the MPR was integrated with the known physical data to assign hatchlings and juveniles to a parent pair. Overall hatchlings and juvenile males trended slightly towards inbreeding, while adult males trended slightly toward outbreeding. I was able to determine parentage for three nests, one nest was consistent with multiple paternity, while the other two were consistent with having only a single sire, but all three nests were at least partially sired by the dominant male. Spatial data combined with MPR showed that non-related individuals are significantly more likely to have overlapping territories than related individuals. Specifically, non-related individuals had 5.3 times more hectares of overlap than related individuals.

Fernandez Blanco, M.V., Cassini, G.H. and Bona, P. (2023). A three-

dimensional geometric morphometric analysis of the morphological transformation of *Caiman* lower jaw during post-hatching ontogeny. PeerJ 11: e15548.

Abstract: Shape ontogenetic changes of the lower jaw in crocodylians are poorly understood. In order to answer some questions related to the inter- and intraspecific morphological variation of the mandible of two extant *Caiman* species, we performed a three-dimensional geometric morphometric approach. For this purpose, we used landmarks and semilandmarks on two ontogenetic mandibular series of 48 and 15 post-hatching specimens of *C. yacare* and *C. latirostris*, respectively. We have also examined the relationship between these anatomical transformations and ontogenetic shifts in diet. We performed a principal component analysis (PCA) for the two species, and regression and partial least squares (PLS) analyses for each species, separately. As a result, species were segregated along the PC1 with specimens of *C. yacare* showing more gracile mandibles, and specimens of *C. latirostris* more robust ones. The PC2 and regression analyses showed an age gradient and represented ontogenetic shape changes. Adult caiman mandibles are higher and wider than juvenile ones, and shape changes are more conspicuous in *C. latirostris*. The PLS analyses showed a significant relationship between shape and diet. Morphological changes of the PLS1 of block-1 match with those of the regression analysis for both species. We have detected morphological transformations in areas where the musculature in charge of mandibular movements is attached. Common morphological changes occurring during ontogeny seem to reflect the same mechanical properties required for crushing and killing in both species, driven by an ontogenetic shift in the diet from invertebrates to vertebrates. Additionally, interspecific differences were also found to be correlated to ontogenetic changes in diet and could be related to dissimilar feeding mechanical requirements (eg stiffness and toughness of the item consumed), and to different habitat preferences. Robust mandibles would be more suitable for shallow and fully vegetated environments, as it can be seen in *C. latirostris*, whereas slender jaws seem to be more suitable for more aquatic species such as *C. yacare*.

Salame-Méndez, A. and Serrano, H. (2023). Neuro-endocrinology of amphibians and reptiles: An overview. International Journal of Zoological Investigations 9(2): 1-32.

Abstract: This review describes the anatomy and histology of the organs that make up the nervous and endocrine systems in amphibians and reptiles. It also includes the effects of the various substances produced by these organs during the ontogeny of both classes of vertebrates.

Li, X., Fu, L., Zhang, S., Wang, Y. and Gao, L. (2023). How alligator immune peptides kill gram-negative bacteria: A lipid-scambling, squeezing, and extracting mechanism revealed by theoretical simulations. International Journal of Molecular Science 24(13) (doi: 10.3390/ijms241310962).

Abstract: *Alligator sinensis* cathelicidins (As-CATHs) are antimicrobial peptides extracted from alligators that enable alligators to cope with diseases caused by bacterial infections. This study assessed the damaging effects of sequence-truncated and residue-substituted variants of As-CATH4, AS4-1, AS4-5, and AS4-9 (with decreasing charges but increasing hydrophobicity) on the membranes of Gram-negative bacteria at the molecular level by using coarse-grained molecular dynamics simulations. The simulations predicted that all the variants disrupt the structures of the inner membrane of Gram-negative bacteria, with AS4-9 having the highest antibacterial activity that is able to squeeze the membrane and extract lipids from the membrane. However, none of them can disrupt the structure of asymmetric outer membrane of Gram-negative bacteria, which is composed of lipopolysaccharides in the outer leaflet and phospholipids in the inner leaflet. Nonetheless, the adsorption of AS4-9 induces lipid scrambling in the membrane

by lowering the free energy of a phospholipid flipping from the inner leaflet up to the outer leaflet. Upon binding onto the lipid-scrambled outer membrane, AS4-9s are predicted to squeeze and extract phospholipids from the membrane, AS4-5s have a weak pull-out effect, and AS4-1s mainly stay free in water without any lipid-extracting function. These findings provide inspiration for the development of potent therapeutic agents targeting bacteria.

Darlim, G., Suraprasit, K., Chaimanee, Y., Tian, P., Yamee, C., Rugbumrung, M., Kaweera, A. and Rabi, M. (2023). An extinct deep-snouted *Alligator* species from the Quaternary of Thailand and comments on the evolution of crushing dentition in alligatorids. *Scientific Reports* 13(1) (doi: 10.1038/s41598-023-36559-6).

Abstract: Fossil *Alligator* remains from Asia are critical for tracing the enigmatic evolutionary origin of the Chinese alligator, *Alligator sinensis*, the only living representative of Alligatoridae outside the New World. The Asian fossil record is extremely scarce and it remains unknown whether *A. sinensis* is an anagenetic lineage or alternatively, extinct divergent species were once present. We provide a detailed comparative description of a morphologically highly distinct *Alligator* skull from the Quaternary of Thailand. Several autapomorphic characters warrant the designation of a new species. *Alligator munensis* sp. nov. shares obvious derived features with *A. sinensis* but autapomorphies imply a cladogenetic split, possibly driven by the uplift of the southeastern Tibetan plateau. The presence of enlarged posterior alveoli in *A. munensis* is most consistent with a reversal to the alligatorine ancestral condition of having crushing dentition, a morphology strikingly absent among living alligatorids. Crushing dentition has been previously considered to indicate an ecological specialisation in early alligatorines that was subsequently lost in *Alligator* spp. However, we argue that there is yet no evidence for crushing dentition reflecting an adaptation for a narrower niche, while opportunistic feeding, including seasonal utilisation of hard-shelled preys, is a reasonable alternative interpretation of its function.

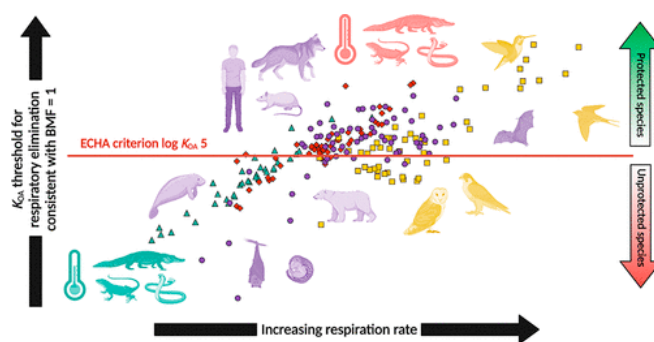
Herod, T.A. (2023). Is the Evolutionary Maintenance of Sex Determination Mechanisms Entirely About Sex? Phenotype Variation as a Function of Incubation Environment. MSc thesis, Southeastern Louisiana University, Hammond, Louisiana, USA.

Abstract: The significance of temperature dependent sex-determination (TSD) is often invoked adaptively with little empirical support. Suggesting a non-adaptive hypothesis behind the evolutionary maintenance of TSD in reptiles should be considered. I hypothesized *A. mississippiensis* cranial shape acts as a viable phenotypic marker of incubation temperature, and morphological disparity is correlated with variation in incubation temperature (measured as thermal effect size, thermal variance, thermal range and average nest temperature). I further tested the hypothesis that morphological disparity and variation in incubation temperature varies between species with different sex determining mechanisms but is higher in TSD taxa than in taxa with genetic sex determination (GSD). Results revealed cranial shape acts as a phenotypic marker of average incubation temperature and disparity varies with thermal effect size and thermal range in *A. mississippiensis*. Data in this study failed to falsify the hypothesis that TSD taxa produce more disparity than GSD taxa under thermal variance and thermal range incubation temperatures. In light of our findings we suggest TSD is not adaptively maintained because of sex differences, rather the production of morphological variation precedes any fitness advantage.

Saunders, L.J. and Wania, F. (2023). Cross-species evaluation of bioaccumulation thresholds for air-breathing animals. *Environment Science & Technology* (https://doi.org/10.1021/acs.est.2c09115).

Abstract: In air-breathing organisms, an organic chemical's

susceptibility to elimination via urinary excretion and respiratory exhalation can be judged on the basis of the octanol-water partition ratio (K_{ow}) and the octanol-air partition ratio (K_{oa}), respectively. Current regulations specify that chemicals with K_{ow} values of $<10^2$ and K_{oa} values of $<10^5$ may be screened as non-bioaccumulative in air breathers. Here we used a model-based approach to evaluate whether these thresholds are consistent with a biomagnification factor of 1 for 141 different mammals, birds, and reptiles. Animals with lower rates of respiration (eg manatees and sloths) and those ingesting high-lipid diets (eg polar bears and carnivorous birds) were predicted to be able to biomagnify persistent chemicals with K_{oa} values of $<10^5$. This was also observed for several temperate reptiles due to their lower respiration rates and internal temperatures. Protective K_{oa} thresholds were determined to be $<10^{4.85}$ for mammals, $<10^{4.60}$ for birds, $<10^{4.60}$ for reptiles at $>25^\circ\text{C}$, and $<10^{3.95}$ for reptiles at $\leq 25^\circ\text{C}$. For all animals, urination alone was not efficient to prevent the biomagnification of any organic chemical. For chemicals with K_{ow} values of $<10^1$, we found that biomagnification of persistent chemicals was constrained by the water-air partition ratio (K_{wa}) rather than K_{oa} . Differences in physiology may need to be considered in bioaccumulation assessments of air-breathing species.



Ramirez-Gonzalez, L., Undiano, E., Flores-Perez, I., Carrillo-D'Lacoste, L., Salmeron, M., Verastegui, A., Lara, G. and Monroy-Noyola, A. (2023). Cu^{2+} -dependent hydrolysis of O-hexyl 2,5-dichlorophenyl phosphoramidate by reptile sera. *Chemo-Biological Interactions* (https://doi.org/10.1016/j.cbi.2023.110637).

Abstract: This study shows the EDTA-resistant, Ca^{2+} and Cu^{2+} -dependent hydrolysis of O-hexyl 2,5-dichlorophenyl phosphoramidate (HDCP) compound in reptiles sera determined by spectrophotometry UV/Vis and chiral chromatography. Samples of ten reptile species were incubated with aliquot of 100 or 400 μM HDCP in presence of 100 or 300 μM Cu^{2+} , or 2.5 mM Ca^{2+} or 5 mM EDTA at 37°C for 30-60 min. The results shown an activator effect of Cu^{2+} on HDCP hydrolysis in freshwater turtles sera (*Trachemys scripta*, *Chelydra serpentina* and *Macrochelys temminckii*) because the levels of 2,5-dichlorophenol (DCP; product hydrolysis) were similar ($\sim 37 \mu\text{M}$ DCP) to chicken serum (positive control group). The marine turtles (*Chelonia mydas* and *Eretmochelys imbricata*) and crocodiles (*Crocodylus acutus* and *Crocodylus moreletii*) showed $\sim 50\%$ less HDCPase activity ($13\text{--}17 \mu\text{M}$ DCP) compared to the HDCPase activity of the freshwater turtle species. Terrestrial reptile species (snakes and lizards) showed around 25% of activity ($7\text{--}13 \mu\text{M}$ DCP) with both copper concentrations. These Cu^{2+} -dependent hydrolysis were stereospecific to R(+)-HDCP ($p < 0.05$) in the three freshwater turtle species that showed similar hydrolysis to the chicken serum. However, the Ca^{2+} did not show a significant activating effect on the HDCPase activity ($1\text{--}8 \mu\text{M}$ DCP) in any reptile serum. Their hydrolysis levels were very similar to those of EDTA-resistant activity. The present study demonstrates a Cu^{2+} -dependent A-esterase (HDCPase) activity in turtles and points serum albumin as the cuproprotein responsible for this activity, reinforcing its N-terminal sequence (DAEH) as a catalytic center.

Sousa Santana, R.L., Lopes de Carvalho, E., Fernandez Conga,

D.M., Mayor Aparicio, P., Assunção Pereira, W.L. and Guerreiro Giese, E. (2023). Redescription of *Brevimulticaecum baylisi* (Nematoda: Heterocheilidae), a parasite of *Caiman crocodilus* (Crocodylia: Alligatoridae) in the north-eastern Peruvian Amazon. *Veterinary Parasitology: Regional Studies and Reports* (doi: 10.1016/j.vprsr.2023.100905).

Abstract: *Caiman crocodilus* is among the most abundant and widely distributed predators in the Neotropical region. These animals consume prey such as crustaceans, birds, small mammals, reptiles, amphibians, and fish, which can carry infective larval forms of nematodes. *Brevimulticaecum* has few studies on its morphology available, lacking detailed images. Therefore, the aim of this study was to redescribe *Brevimulticaecum baylisi*, stomach parasite of *Caiman crocodilus*, from subsistence hunting in the Yavari-Mirin River, Peruvian Amazon, using light and scanning electron microscopy. Four caimans were analyzed, and, macroscopically, all had ulcerative lesions in the stomach caused by this parasite. Histopathology showed an inflammatory infiltrate with a predominance of lymphocytes. Morphological characteristics of nematodes include the presence of three diamond-shaped lips wider than they are long, interlabia pyramidal, excretory pore located above the nerve ring, present intestinal cecum, ventriculus with five ventricular appendages, and long, winged spicules. These morphological characters, added to the number and distribution of the pre- and postcloacal papillae of the male specimens, allowed the identification of these parasites as *B. baylisi*. Scanning electron microscopy of these nematodes showed the presence of a denticulous ridge on the inner surface of the lips in both sexes, while in males, the presence of a horseshoe-shaped median papilla was observed on the upper lip of the cloaca. Our research, therefore, adds these characteristics to the original description of *B. baylisi*, in addition to expanding the biogeographical distribution of this parasite.

Girard, L.C., De Sousa Oliveira, S., Raselli, I., Martin, J.E. and Anquetin, J. (2023). Description and phylogenetic relationships of a new species of *Torvoneustes* (Crocodylomorpha, Thalattosuchia) from the Kimmeridgian of Switzerland. *PeerJ* 11: e15512.

Abstract: Metriorhynchids are marine crocodylomorphs found across Jurassic and Lower Cretaceous deposits of Europe and Central and South America. Despite being one of the oldest fossil families named in paleontology, the phylogenetic relationships within Metriorhynchidae have been subject to many revisions over the past 15 years. Herein, we describe a new metriorhynchid from the Kimmeridgian of Porrentruy, Switzerland. The material consists of a relatively complete, disarticulated skeleton preserving pieces of the skull, including the frontal, prefrontals, right postorbital, nasals, maxillae, right premaxillae and nearly the entire mandible, and many remains of the axial and appendicular skeleton such as cervical, dorsal, and caudal vertebrae, ribs, the left ischium, the right femur, and the right fibula. This new specimen is referred to the new species *Torvoneustes jurensis* sp. nov. as part of the large-bodied macrophagous tribe Geosaurini. *Torvoneustes jurensis* presents a unique combination of cranial and dental characters including a smooth cranium, a unique frontal shape, acute ziphodont teeth, an enamel ornamentation made of numerous apicobasal ridges shifting to small ridges forming an anastomosed pattern toward the apex of the crown and an enamel ornamentation touching the carina. The description of this new species allows to take a new look at the currently proposed evolutionary trends within the genus *Torvoneustes* and provides new information on the evolution of this clade.

Stephens, R.B., Shipley, O.N. and Moll, R.J. (2023). Meta-analysis and critical review of trophic discrimination factors ($\Delta^{13}\text{C}$ and $\Delta^{15}\text{N}$): Importance of tissue, trophic level and diet source. *Functional Ecology* (https://doi.org/10.1111/1365-2435.14403).

Abstract: Robustly quantifying dietary resource use and trophic

position using stable isotopes requires accurate trophic discrimination factors (TDF; $\Delta^{13}\text{C}$ and $\Delta^{15}\text{N}$ for carbon and nitrogen, respectively), defined as the isotopic difference between consumer and diet. Early TDF studies converged on values of around 1.0‰ for $\Delta^{13}\text{C}$ and 3.4‰ for $\Delta^{15}\text{N}$ but more recent work indicates that TDF values may be more nuanced, depending on taxa, tissues, trophic level and diets. Yet, the relative importance of these factors remains unclear. Focusing on vertebrates (birds, fish, herpetiles and mammals), we conducted a literature review of 279 studies that estimated TDF values and used a Bayesian framework to determine how tissue type, trophic level and diet source influence variation in $\Delta^{13}\text{C}$ and $\Delta^{15}\text{N}$. Additionally, we reviewed 358 trophic ecology studies to determine if studies accounted for these factors during their TDF selection process. For $\Delta^{13}\text{C}$, vertebrates showed consistent patterns among tissue types (likely influenced by amino acid composition) and between trophic levels and diet sources (likely a result of dietary protein content and metabolic routing). Comparatively, for $\Delta^{15}\text{N}$, vertebrates showed considerable variation among tissue types and trophic levels, likely due to differences in tissue synthesis and physiological capabilities. Overall, $\Delta^{13}\text{C}$ ranged from -5.1‰ to 9.1‰ and $\Delta^{15}\text{N}$ from -3.3‰ to 9.7‰, underscoring that 1.0‰ for $\Delta^{13}\text{C}$ and 3.4‰ for $\Delta^{15}\text{N}$ are not universally appropriate. Moreover, both $\Delta^{13}\text{C}$ and $\Delta^{15}\text{N}$ varied by more than 9‰ within a single species and tissue type, demonstrating that using TDF values from the same, or similar, species may not be appropriate if diet and trophic level are not considered. Despite the importance of diet source on TDF values, most trophic ecology studies did not account for it. Further, most fish studies relied on literature review values that failed to account for tissue type, trophic level and diet source. To aid ecologists in diet and trophic assessments of vertebrates, we used our meta-analysis to model taxon-specific TDF estimates (mean \pm SD) for each tissue type, trophic level and diet source combination. These more refined TDF values should improve ecological assessments that use stable isotopes.

Bourke, J.M. and Witmer, L.M. (2023). Soft tissues influence nasal airflow in diapsids: Implications for dinosaurs. *Journal of Morphology* (https://doi.org/10.1002/jmor.21619).

Abstract: The nasal passage performs multiple functions in amniotes, including olfaction and thermoregulation. These functions would have been present in extinct animals as well. However, fossils preserve only low-resolution versions of the nasal passage due to loss of soft-tissue structures after death. To test the effects of these lower resolution models on interpretations of nasal physiology, we performed a broadly comparative analysis of the nasal passages in extant diapsid representatives, eg alligator, turkey, ostrich, iguana, and a monitor lizard. Using computational fluid dynamics, we simulated airflow through 3D reconstructed models of the different nasal passages and compared these soft-tissue-bounded results to similar analyses of the same airways under the lower-resolution limits imposed by fossilization. Airflow patterns in these bony-bounded airways were more homogeneous and slower flowing than those of their soft-tissue counterparts. These data indicate that bony-bounded airway reconstructions of extinct animal nasal passages are far too conservative and place overly restrictive physiological limitations on extinct species. In spite of the diverse array of nasal passage shapes, distinct similarities in airflow were observed, including consistent areas of nasal passage constriction such as the junction of the olfactory region and main airway. These nasal constrictions can reasonably be inferred to have been present in extinct taxa such as dinosaurs.

Hogan, J.D. and Varricchio, D.J. (2023). Chthonic severance: dinosaur eggs of the Mesozoic, the significance of partially buried eggs and contact incubation precursors. *Philosophical Transactions of the Royal Society B* (https://doi.org/10.1098/rstb.2022.0144).

Abstract: For most dinosaurs, clutches consisted of a single layer of spherical to sub-spherical, highly porous eggs that were probably

fully buried. Both eggs and clutch form change drastically with pennaraptoran theropods, the clade that includes birds. Here, far less porous, more elongate eggs are arranged with additional complexity, and only partially buried. While partial egg burial seems to be effective for an extremely small group of modern birds, the behaviour's overall rarity complicates our understanding of Mesozoic analogies. Recent experimental examination of pennaraptoran nesting thermodynamics suggests that partial egg burial, combined with contact incubation, may be more efficacious than has been presumed. We propose that nest guarding behaviour by endothermic archosaurs may have led to an indirect form of contact incubation using metabolic energy to affect temperature change in a buried clutch through a barrier of sediment, which in turn may have selected for shallower clutch burial to increasingly benefit from adult-generated energy until partial egg exposure. Once partially exposed, continued selection pressure may have aided a transition to fully subaerial eggs. This hypothesis connects the presence of partially buried dinosaurian clutches with the transition from basal, crocodile-like nesting (buried clutches guarded by adults) to the dominant avian habit of contact incubating fully exposed eggs.

Werneck, M.R., Menezes, P.Q., Alvarenga, F.P., Dias, G.G., Ornellas, I.S., Machado, Y., Costa, L.P., Filho, P.R.J. and Nóbrega, Y.C. (2023). First report of *Pseudotolorchis yacarei* Catto & Amato, 1993 (Telorchidae) in *Caiman latirostris* (Daudin, 1802) (Alligatoridae) in Brazil. *Neotropical Helminthology* 17(1): 83-87.

Abstract: *Caiman latirostris* (Daudin, 1802) occurs in South America, where its geographic distribution extends down to Uruguay. Very little is known about helminths of *C. latirostris*; therefore, the present study reports the first occurrence of *Pseudotolorchis yacarei* Catto & Amato, 1993 in these animals. Six young and juvenile specimens of *C. latirostris* were collected in Caravelas, Bahia, Brazil. The animals were necropsied and six animals had their digestive tracts evaluated for further analysis. In 5 of the 6 hosts analyzed, 16 specimens of *P. yacarei* were collected from the stomach and small intestine with a prevalence of 83%. Hence, this study presents the broad-snouted caiman as a new host of *P. yacarei*.

Brownstein, C.D. (2023). A late-surviving phytosaur from the northern Atlantic rift reveals climate constraints on Triassic reptile biogeography. *BMC Ecology and Evolution* 23(1) (doi: 10.1186/s12862-023-02136-8).

Abstract: The origins of all major living reptile clades, including the one leading to birds, lie in the Triassic. Following the largest mass extinction in Earth's history at the end of the Permian, the earliest definite members of the three major living reptile clades, the turtles (Testudines), crocodylians and birds (Archosauria), and lizards, snakes, amphisbaenians, and Tuatara (Lepidosauria) appeared. Recent analyses of the Triassic reptile fossil record suggest that the earliest diversifications in all three of these clades were tightly controlled by abrupt paleoclimate fluctuations and concordant environmental changes. Yet, this has only been preliminarily tested using information from evolutionary trees. Phytosauria consists of superficially crocodylian-like archosaurs that either form the sister to the crown or are the earliest divergence on the crocodylian stem and are present throughout the Triassic, making this clade an excellent test case for examining this biogeographic hypothesis. Here, I describe a new phytosaur, *Jupijkam paleofluvialis* gen. et sp. nov., from the Late Triassic of Nova Scotia, Canada, which at that time sat in northern Pangaea near the northern terminus of the great central Pangean rift. As one of the northernmost occurrences of Phytosauria, *J. paleofluvialis* provides critical new biogeographic data that enables revised estimations of phytosaur historical biogeography along phylogenies of this clade built under multiple methodologies. Reconstructions of phytosaur historical biogeography based on different phylogenies and biogeographic models suggest that phytosaurs originated in northern Pangaea, spread southward, and then dispersed back northward at least once

more during the Late Triassic. The results presented in this study link phytosaur biogeography to major changes to Triassic global climate and aridity. Together with the earliest dinosaurs and several other reptile lineages, phytosaur diversification and migration appear to have been restricted by the formation and loss of arid belts across the Pangean supercontinent.

Barão-Nóbrega, J.A.L., González-Jáuregui, M., Padilla-Paz, S., Maher, K.H., Martínez-Arce, A., Cedeño-Vázquez, J.R. and Jehle, R. (2023). Characterising a genetic stronghold amidst pervasive admixture: Morelet's crocodiles (*Crocodylus moreletii*) in central Yucatan. *Conservation Genetics* (<https://doi.org/10.1007/s10592-023-01544-z>).

Abstract: When backcrosses are fertile, interbreeding between endangered taxa can lead to the admixture of gene pools under threat. One such case pertains to the Mesoamerican crocodile *Crocodylus moreletii*, a species which shows strong signatures of both recent hybridisation and historic introgression with the American crocodile *C. acutus* across large parts of its range. In the present paper, we use RAD-seq derived SNPs (4980 nuclear and seven mtDNA loci) to demonstrate that *C. moreletii* populations inhabiting the region of Calakmul in central Yucatan (Mexico) are rather unaffected by hybridization, despite being surrounded by coastal areas where pervasive admixture has previously been documented. All (based on fastSTRUCTURE) and 96% (based on NGSadmix) of 84 genotyped individuals from 18 sampled waterbodies (locally termed aguadas) were free from nuclear introgression of *C. acutus* DNA at at threshold of 0.95. Seven individuals (8%) possessed a *C. acutus* mtDNA haplotype, five of which were derived from two adjacent, rather peripheral aguadas. Spatial inferences based on a DAPC and fineRADstructure further showed that the region of Calakmul is inhabited by three genetic clusters spanning across a set of distinct aguadas each. Taken together, our findings reveal that central Yucatan contains the currently largest documented stronghold of *C. moreletii* populations only marginally affected by introgression, which has major implications for the conservation management of this important flagship species.

Das, C.S., Mandal, R.N. and Bandyopadhyay, S. (2023). Reviewing the issues of human-carnivore conflict vis-a-vis mitigation approaches of the Indian Sundarban. *Environmental Development* 47 (<https://doi.org/10.1016/j.envdev.2023.100888>).

Abstract: Sundarban, the single largest mangrove block in the world, is shared by India and Bangladesh. It has a rich biodiversity that provides staggering ecosystem services to local inhabitants for their livelihoods. Its top carnivores, tigers on land and crocodiles in the water, seem to protect the entire ecosystem, but lead to human-carnivore conflicts. Gradual ingress of saline water through tidal flooding into the rivers and creeks causes a threat to primary farming such as agriculture and aquaculture. Owing to the steady decline of earnings from farming, people living in the fringe zones of the forested lands are compelled to enter into the protected areas for collecting bio-resources without valid permits, resulting in inevitable conflicts with carnivores. In this context, a meta-analysis of human-carnivore conflict was done in the Sundarban to find out the causes, pattern, and trend of conflict of each type considering a variety of temporal, spatial, and societal parameters in order to provide a better understanding of the comparison to similar conflicts worldwide. These conflicts account for poor agriculture in one way and economically potential bio-resources in another, compelling local inhabitants to depend upon forest resources. To mitigate the conflict, there have been selective measures implemented. We review these measures as categorized into three different types, such as i) innovative approaches, conceptualized and then implemented ii) conventional approaches, applied when needed, and iii) protective approaches established for the conservation of both tigers and crocodiles. We synthesize the entire prevailing system and suggest a comprehensive conservation plan for the application that is flexible,

involving adaptive management, a continuous process tested through trial and error. In this plan, actions are accessed, adapted, and tested again, eventually leading to a coexistence that is acceptable to the affected people and enables the tigers and crocodiles to continue playing their ecological function.

Mainwaring, M.C., Medina, I., Tobalske, B.W., Hartley, I.R., Varricchio, D.J. and Hauber, M.E. (2023). The evolution of nest site use and nest architecture in modern birds and their ancestors. *Philosophical Transactions of the Royal Society B* (<https://doi.org/10.1098/rstb.2022.0143>)

Abstract: The evolution of nest site use and nest architecture in the non-avian ancestors of birds remains poorly understood because nest structures do not preserve well as fossils. Nevertheless, the evidence suggests that the earliest dinosaurs probably buried eggs below ground and covered them with soil so that heat from the substrate fuelled embryo development, while some later dinosaurs laid partially exposed clutches where adults incubated them and protected them from predators and parasites. The nests of euornithine birds - the precursors to modern birds - were probably partially open and the neornithine birds - or modern birds - were probably the first to build fully exposed nests. The shift towards smaller, open cup nests has been accompanied by shifts in reproductive traits, with female birds having one functioning ovary in contrast to the two ovaries of crocodilians and many non-avian dinosaurs. The evolutionary trend among extant birds and their ancestors has been toward the evolution of greater cognitive abilities to construct in a wider diversity of sites and providing more care for significantly fewer, increasingly altricial, offspring. The highly derived passerines reflect this pattern with many species building small, architecturally complex nests in open sites and investing significant care into altricial young.

Luthfiana, S. (2023). Kepadatan Populasi dan Distribusi Buaya Senyulong (*Tomistoma schlegelii*) di Taman Nasional Sebangau, Kalimantan Tengah. MSc thesis, Universitas Gadjah Mada, Yogyakarta, Indonesia.

Abstract: False gharial (*Tomistoma schlegelii*) was an endemic crocodile species that distribution limited to Southeast Asia. False gharial known as a freshwater crocodile species that needs attention because one of the list of protected animals. Human interventions has resulted in habitat changes and affected population change. This study aims to estimate the value of population density and describe the spatial distribution and identify the distribution pattern of false gharial in Sebangau River and Bangah River, Sebangau National Park, Central Kalimantan. Data were collected in Bangah River and Sebangau River for 23 effective days. The method used to determine population density was VES (Virtual Encounter Survey) method combine with a line transect following the river flow and the spotlight survey method for false gharial encounters. Data analysis of population density was obtained by calculating the number of individuals divided by the study area. Meanwhile, the spatial distribution was visualized using maps processed by ArcGIS 10.8 software and the distribution pattern was analyzed using the standardized Morisita Index. The results showed that the population density of false gharial in Sebangau National Park during the rainy season in Sebangau River was 0.9044 individuals/km². The spatial distribution of false gharial was illustrated through a distribution map. The spatial distribution of false gharial is uneven and only found in Sebangau River. The distribution pattern formed was clumped. Management recommendastions for population conservation include monitoring and fostering the habitat of false gharial in Sebangau River, Sebangau National Park.

Saldarriaga-Gómez, A.M., Ardila-Robayo, M.C., Medem, F. and Vargas-Ramírez, M. (2023). Hope is the last thing lost: Colombian captive-bred population of the critically endangered Orinoco crocodile (*Crocodylus intermedius*) is a genetic reservoir that could

help to save the species from extinction. *Nature Conservation* 53: 85-103.

Abstract: A purpose of *ex-situ* populations is the preservation of genetic variation, but this is a challenging task since genetic diversity is commonly lost through each generation, and so the establishment of management guidelines should be a high priority. Fifty years ago, the National University of Colombia began a breeding program in the Roberto Franco Tropical Station (in Villavicencio, Meta) to conserve the critically endangered Orinoco crocodile *Crocodylus intermedius*. Despite the large number of individuals raised and kept in captivity, the Station has not been able to release individuals due to a lack of a complete genetic characterization that could determine whether the population is genetically viable. In this study we used a panel of 17 microsatellite loci to overcome this problem. We estimated from the founder animals and the live crocodiles the inbreeding, heterozygosities, the number of alleles, and their richness, and frequencies to understand the effects of managing a captive breeding program without considering genetic profiles. Our results revealed that the living population maintains much of its founder diversity with high levels of heterozygosity and low overall inbreeding, making it suitable for maintaining captive breeding and for implementing wild releases. We estimated the individual genetic diversity of the living crocodiles, as well as their relationships. This information, combined with the size, sex, and location, allowed us to propose combinations and to restructure the breeding groups. We demonstrated that molecular data could be used to improve the management of *ex-situ* conservation programs well beyond what could be achieved with pedigree information alone.

Gupta, S. and Clark, J. (2023). How to manage soft tissue infections and injuries in low- and middle-income countries. Pp. 435-440 in *Global Surgery*, ed. by M.A. Hardy and B.R. Hochman. Springer: Cham.

Abstract: Soft tissue infections are challenging surgical problems, which can be limb- and life-threatening. Soft tissue infections can range from cellulites to necrotizing soft tissue infections and differ depending on the cause of the infection. Key in management and potentially life-saving is the ability to differentiate and diagnose the latter in a timely fashion and offer prompt surgical care when needed. Though many different infections are described below, the principles of urgent, aggressive surgical debridement and appropriate antibiotic coverage exist throughout.

Sales-Oliveira, V., Altmanová, M., Gvoždík, V., Kretschmer, R., Ezaz, T., Liehr, T., Padutsch, N., Badjedjea, G., Utsunomia, R., Tanomtong, A. and Cioffi, M. (2023). Cross-species chromosome painting and repetitive DNA mapping illuminate the karyotype evolution in true crocodiles (Crocodylidae). *Chromosoma* ([doi: 10.1007/s00412-023-00806-6](https://doi.org/10.1007/s00412-023-00806-6)).

Abstract: Crocodilians have maintained very similar karyotype structures and diploid chromosome numbers for around 100 million years, with only minor variations in collinearity. Why this karyotype structure has largely stayed unaltered for so long is unclear. In this study, we analyzed the karyotypes of six species belonging to the genera *Crocodylus* and *Osteolaemus* (Crocodylidae, true crocodiles), among which the Congolian endemic *O. osborni* was included and investigated. We utilized various techniques (differential staining, fluorescence *in situ* hybridization with repetitive DNA and rDNA probes, whole chromosome painting, and comparative genomic hybridization) to better understand how crocodile chromosomes evolved. We studied representatives of three of the four main diploid chromosome numbers found in crocodiles (2n= 30/32/38). Our data provided new information about the species studied, including the identification of four major chromosomal rearrangements that occurred during the karyotype diversification process in crocodiles. These changes led to the current diploid chromosome numbers of 2n= 30 (fusion) and 2n= 38 (fissions), derived from the ancestral

state of $2n=32$. The conserved cytogenetic tendency in crocodylians, where extant species keep near-ancestral state, contrasts with the more dynamic karyotype evolution seen in other major reptile groups.

Boerman, S.A., Vellekoop, J., Jouve, S., Oudoire, T. and Smith, T. (2023). New specimens and CT data of the longirostrine crocodylian *Thoracosaurus isorhynchus* from the Maastrichtian of Mont-Aimé (Paris Basin, France). Abstract, 20th Annual Conference of the European Association of Vertebrate Palaeontologists. European Association of Vertebrate Palaeontologists: Spain.

Abstract: Thoracosaurus are a polyphyletic group of Cretaceous-Paleogene longirostrine crocodylians from Europe and North America. Traditionally perceived as gavialoids, phylogenetically closer to Gavialinae than to Tomistominae, they play a key role in the gharial problem: their old age and seemingly close relationship to Gavialinae is inconsistent with molecular clock estimates indicating a far younger origin of Gavialoidea. Moreover, the phylogenetic position of thoracosaurus is debated, as recent studies suggested thoracosaurus are non-crocodylian eusuchians instead. Here we describe thoracosaur material from Mont-Aimé, France, rediscovered in the collections of the Musée d'Histoire Naturelle de Lille. The Mont-Aimé is famous for its richness in fossil vertebrates, among which the longirostrine species *Thoracosaurus isorhynchus* (formerly *T. macrorhynchus*). Confusion about the age of the vertebrate layers has recently been solved, indicating that they are Maastrichtian in age instead of Danian. The new material most likely belongs to *T. isorhynchus* based on a flexure in the ectopterygoid-pterygoid suture, a distinctive character found in adults of this taxon. Our study reveals new characters not visible on previously known material. An example is the short posterior non-dentigerous process of the maxilla, a character shared with early Paleogene longirostrines and tomistomines but not with gavialines. Furthermore, microCT data of the skull reveal for the first time endocranial characters of this taxon, such as the presence of an internal recess in the parietal. Together with redescribed *T. isorhynchus* material from the Muséum d'Histoire Naturelle, Paris, this leads to an updated phylogenetic position of this taxon.

Pritz, M.B. (2023). Nuclei and tracts in the epithalamus of crocodiles. *Journal of Comparative Neurology* (doi: 10.1002/cne.25531).

Abstract: The epithalamus, an area of the dorsal diencephalon found in all vertebrates, consists of the habenula, the subhabenular nuclei, and associated tracts. The habenula is itself divisible into two parts—a medial and a lateral nucleus differing in their inputs, outputs, and cellular morphology. The medial component is related to the limbic system and serotonergic raphe, while the lateral nucleus is more interconnected with the basal ganglia and midbrain dopamine systems. These findings, which come from experiments mainly done on mammals, serve as a basis for comparison with other vertebrates. However, similar studies in other amniotes, such as reptiles, are few. To fill this gap in knowledge, two species of crocodiles were examined utilizing a variety of histological methods in various planes of section. The following results were obtained. First, the habenula was divided into medial and lateral parts based on its cytoarchitecture. Neurons in the medial habenula were small, were closely packed, and had a limited dendritic arbor characterized by unusual distal dendritic appendages, whereas neurons in the lateral habenula were larger, were more loosely packed, and had longer dendritic processes that were commonly beaded. Second, the stria medullaris, the major input to the habenula, was identified by its immunoreactivity to parvalbumin. Third, the fasciculus retroflexus (habenulointerpeduncular tract), the primary output of the habenula, was visualized by staining with acetylcholinesterase. Fourth, nuclei associated with the habenula, the subhabenular nuclei, have been identified and characterized. These features provide a means to recognize the major nuclei and tracts in the epithalamus in crocodiles and are likely applicable to other reptiles.

Parunyakul, K., Chuchoiy, A., Kooltueon, S., Puttagamnerd, P., Srisuksai, K., Santativongchai, P., Pongchairerk, U., Tulayakul, P., E-Kobon, T. and Fungfuang, W. (2023). Effect of the oil from the fatty tissues of *Crocodylus siamensis* on gut microbiome diversity and metabolism in mice. *PLoS One* 18(7): e0289073.

Abstract: Dietary fat can alter host metabolism and gut microbial composition. Crocodile oil (CO) was extracted from the fatty tissues of *Crocodylus siamensis*. CO, rich in monounsaturated- and polyunsaturated fatty acids, has been reported to reduce inflammation, counter toxication, and improve energy metabolism. The aim of this study was to investigate the effect of CO on gut microbiota (GM) in laboratory mice as well as the accompanying metabolic changes in the animals. Forty-five C57BL/6 male mice were randomly divided into five groups and orally administered either sterile water (control [C]); 1 or 3% (v/w) CO (CO-low [CO-L] and CO-high [CO-H], respectively); or 1 or 3% (v/w) palm oil (PO-low and PO-high, respectively) for 11 weeks. Body weight gain, food intake, energy intake, blood glucose levels, and blood lipid profiles were determined. Samples from colon tissue were collected and the 16S rRNA genes were pyrosequenced to clarify GM analyses. The results showed that there were no differences in body weight and blood glucose levels. Food intake by the mice in the CO-L and CO-H groups was statistically significantly less when compared to that by the animals in the C group. However, neither CO treatment had a statistically significant effect on calorie intake when compared to the controls. The CO-H exhibited a significant increase in serum total cholesterol and low-density lipoprotein but showed a downward trend in triglyceride levels compared to the control. The GM analyses revealed that both CO treatments have no significant influence on bacterial diversity and relative abundance at the phylum level, whereas increases of *Chao1* and abundance-based coverage estimator indexes, distinct β -diversity, and Proteobacteria abundance were observed in the PO-high group compared with the C group. Furthermore, the abundance of *Azospirillum thiophilum* and *Romboutsia ilealis* was significantly higher in the CO-L and CO-H groups which could be associated with energy metabolic activity. Thus, CO may be an alternative fat source for preserving host metabolism and gut flora.

Klein, H. and Heckert, A.B. (2023). *Chirotheres: Tracking the Ancestors of Dinosaurs and Crocodiles*. Indiana University Press: Indiana, USA.

Murphy, K. (2023). *The Influence of Environmental Variation on the Microbiome during Early-life Stages in Reptiles*. PhD thesis, Auburn University, Auburn, Alabama, USA.

Abstract: My dissertation research seeks to understand how environmental variation, including maternal effects, might influence the microbiome of reptiles and how those differences translate to phenotypic variation. My research framework integrates both observational and experimental science through field and lab-based methods. Documenting environmentally mediated changes in the microbiome and their effects on hosts will provide a robust foundation for understanding the role of microbiome plasticity in shaping host phenotypes, including growth, physiology, and behavior. For my first chapter, I sought to understand how gut homeostasis is influenced by environmental variation (in the form of aquatic pollutants like estrogen). I experimentally assigned 23 hatchling American alligators (*Alligator mississippiensis*) to three ecologically relevant treatments (control, low, and high estrogen concentrations) for ten weeks. Gut microbial samples were collected following diet treatments and microbial diversity was determined using 16S rRNA gene-sequencing. Individuals in estrogen-treatment groups had decreased microbial diversity, but a greater relative abundance of operational taxonomic units than those in the control group. This effect was dose-dependent; as individuals were exposed to more estrogen, their microbiota became less diverse, less rich, and less even. Findings from this study suggest that environmental

contamination can influence wildlife populations at the internal, microbial level, which may lead to future deleterious health effects. For my second chapter, I sought to effectively sample and manipulate the microbiome of eggshells. Although most vertebrates are oviparous, little is known about microorganisms on the surface of eggshells and their functions, particularly on eggs of non-avian reptiles. I developed a novel method to effectively sample (ie whole-egg sonication) and manipulate the eggshell microbiome of non-avian reptiles while minimizing contamination from external sources. Overall, my results provide useful guidelines for future manipulative studies that examine the source and function of the eggshell microbiome. For my third chapter, I experimentally manipulated the maternal gut microbiome using antibiotics and evaluate consequences on offspring phenotype in the brown anole lizard (*Anolis sagrei*). DNA was extracted from maternal gut tissue and cloacal samples and sequenced at the 16S rRNA gene. Eggs were incubated and embryo/hatchling phenotypes were recorded (eg survival, hatchling morphology). I found that treatment mothers had reduced gut microflora diversity and produced larger eggs/hatchlings than control mothers. Findings from this study provide new insight into the role of maternal gut microbiota and its potential functional significance on offspring. For my concluding chapter, I conducted a systematic review on vertical transmission of microbiota in non-human animals. I found that many studies examining vertical transmission of microbiomes fail to collect whole microbiome samples from both maternal and offspring sources, particularly for oviparous vertebrates. An ideal microbiome study incorporates host factors, microbe-microbe interactions, and environmental factors. Together, results from my dissertation suggest that the gut microbiome is highly influenced by environmental variation, including maternal effects, in ways that may affect offspring fitness. As evolutionary biologists continue to merge microbiome science and ecology, examining microbiomes in oviparous taxa may provide insight into how microbiota shape host phenotypes.

Flint, M., Sagera, K., Wainwright, K. and Flint, J.B. (2023). Field based assessment of clinical signs of irreversible loss of consciousness and death confirmed by brain destruction in juvenile American alligators (*Alligator mississippiensis*) after penetrating captive bolt stunning or electrostunning with probe pithing. *Journal of Applied Animal Welfare Science* (doi: [10.1080/10888705.2023.2236550](https://doi.org/10.1080/10888705.2023.2236550)).

Abstract: To determine the humane use of slaughter methods we examined the clinical signs of life in 61 American alligators harvested on-farm using one of three methods: (i) captive bolt and spinal cord severance; (ii) electrostunning, spinal cord severance and pithing; and (iii) spinal cord severance and pithing. Loss of consciousness and the six clinical signs of life that can be used on-farm were assessed for evidence of irreversible unconsciousness and death at Time 0, 0.5, 1, 2, 5, 10, 20, and 30 min post slaughter. The brains of alligators from each slaughter method were removed to assess brain tissue disruption. A combination of loss of blink reflex, pupillary light response, jaw tone and respiration are a reliable on-farm tool for determining death. Heartbeat and withdrawal reflex persisted. Captive bolt and electrostunning methods were effective in immediately producing loss of response consistent with irreversible unconsciousness, subsequent death and destruction of neural tissue integrity in the mid and hind brain. They are therefore humane forms of slaughter in American alligators.

Ahmad, R. and Shrivastava, M.S. (2023). An eco-friendly management of organic waste and recycling of pond water of zoo aquatic animals by using *Eudrilus eugeniae* in Gandhi Zoological Park: A case study of vermicompost maturity. *Environmental Quality Management* (doi: [10.1002/tqem.22081](https://doi.org/10.1002/tqem.22081)).

Abstract: Zoo waste is a common problem in urban areas, as it overloads municipalities. To enhance the park's appeal, sustainability, and cleanliness, a pilot vermicomposting process was implemented as an alternative for organic waste disposal. It aimed

to address the negative effects of poor organic waste management. Three types of pond water, namely hippopotamus, crocodile, and gharial, were recycled. Additionally, ostrich droppings and the nitrogenous compounds abundant in carnivore feces were utilized. The study sought to improve organic waste management and recycle pond water using exotic worms. Chemical and physical analyses were conducted on pond water and vermicompost obtained from Gandhi Zoological Park, revealing their high nutrient content. Fourier transform infrared spectroscopy was employed to study the functional groups present in the compost and vermicompost, allowing the detection of vermicompost maturity. The biomass of exotic earthworms, as well as the count of cocoons, juveniles, and adults, was assessed during different seasons of the year. This approach facilitated the recycling of pond water and the reduction of organic waste within the zoo premises. It involved the symbiotic cooperation of earthworms and bacterial colonies, transforming the waste into a high-quality product with balanced macronutrients. The novelty of the study lies in its focus on nutrient recycling in pond water, ostrich droppings, and vermicomposting of organic waste from carnivores.

Putra, A.A., Yoza, D. and Setyawatiningsih, S.C. (2023). The diversity of reptile species in mangrove ecotourism of Kampung Rawa Mekar Jaya, Siak Regency. *Jurnal Pembelajaran dan Biologi Nukleus* 9(2) (doi: <https://doi.org/10.36987/jpbn.v9i2.4266>).

Abstract: Rawa Mekar Jaya mangrove ecotourism is the last mangrove forest on the east coast of Sumatra Island. This mangrove forest is a home for reptiles. The reptilian fauna of the Mekar Jaya mangrove has the potential to become an ecotourism object. This study aims to determine the diversity, evenness, abundance, and status of reptile species in the Mekar Jaya mangrove ecotourism. Four 3 x 400 m transects were conducted in two habitat types: aquatic (10 m of bank) and terrestrial (30 m of bank). Observations were made in the morning and evening at low tide and repeated five times at three-day intervals. Direct collection of reptile data using a visual survey (VES) and passive sampling (glue trap). The researchers managed to capture 52 individuals, which were reptiles, consisting of 4 species (*Draco sumatranus*, *Hemidactylus platyurus*, *Mabuya multifasciata*, and *Varanus savator*) found directly in the field. The results of the interviews with the managers indicate that there are 2 species of crocodiles: *Crocodylus porosus* and *Tomistoma schlegelii*. Shannon-Wiener diversity index value was medium ($H' = 1.02$). Evenness index was labile (0.57). The highest species abundance was *M. multifasciata* (0.65), while the lowest abundance was *H. platyurus* (0.12). All reptile species found were not protected. *V. savator* is classified as a low-risk species (LC/Minor Concern) and is listed in Appendix II of CITES. Two crocodile species reported by the community are protected. *T. schlegelii* is vulnerable and listed in Appendix I of CITES. *C. porosus* is low-risk and listed in CITES Appendix II.

Helm, C.W. (2023). Pleistocene Vertebrate Trace Fossils from the Cape South Coast of South Africa: Inferences and Implications. PhD thesis, Nelson Mandela University South Africa.

Abstract: Palaeoichnology, the study of fossil tracks and traces, has had a relatively late start on the Cape south coast of South Africa. Since its inception in 2007 the Cape south coast ichnology project has led to the identification of 326 Pleistocene vertebrate ichnosites in aeolianites (cemented dunes) and cemented foreshore deposits between the community of Arniston in the west and the Robberg Peninsula in the east, a distance of approximately 350 kilometres. As a result, significant palaeoenvironmental, palaeoecological and palaeoanthropological inferences have been made. This thesis brings together this corpus of work, and attempts to answer the question of how ichnology can inform the understanding of the Cape south coast Pleistocene environment, and how the trace fossil record can complement the body fossil record. Achieving this objective involves the development of a definitive regional account. This

includes descriptions of the regional geological context, Quaternary sea-level changes, and the state of knowledge of the region's Pleistocene palaeoenvironment, palaeoanthropology, and body fossil record, along with an understanding of the roles of substrate and taphonomy in regional ichnology. A discussion of geochronology includes the age results from specimens submitted for dating through optically stimulated luminescence - dated deposits range in age from Marine Isotope Stage 11 through Marine Isotope Stage 3. The body of the thesis is formed by systematic descriptions of the vertebrate ichnosites, accompanied by interpretation and comments. Three databases have been compiled: ichnosites, photographs, and photogrammetry images. In synthesizing this data, four underlying questions are addressed: what is the global relevance of the Cape south coast ichnosites, how can these studies complement the vertebrate body fossil record, how can they contribute to the understanding of Pleistocene palaeoenvironments and palaeoecology, and how can they contribute to palaeoanthropology? The Cape south coast is of global ichnological importance. Unanticipated findings which augment the sparse reptilian body fossil record include tracks and traces of crocodiles, monitor lizards, very large tortoises (the first of their kind in the global record), and hatching sea turtles. Two new ichnogenera have been erected to describe the sea turtle tracks, each containing a new ichnospecies: *ustralochelichnus agulhasii* and *Marinerichnus latus*. Avian ichnosites are the oldest in southern Africa, and include the presence of tracks of larger-than-expected birds, which may represent large chronosubspecies or may suggest the possibility of extinctions which are not evident from the body fossil record. Unique examples of the non-hominin mammalian ichnosites include sand-swimming traces that resemble those of the 'Namib mole': as a result a new ichnogenus (*Natatorichnus*) has been erected, containing two ichnospecies, *N. subarenosa* and *N. sulcatus*. The first elephant trunk-drag impressions and the first pinniped ichnosites in the global record have been identified. The role of elephant tracks as precursors to coastal potholes was previously unsuspected. Equid tracksites indicate a widespread presence of the extinct giant Cape horse (*Equus capensis*). The identification of a giraffe tracksite represents a major range extension. In particular, tracks and traces of giraffe, crocodiles, breeding sea turtles, and sand-swimming golden moles have significant palaeoenvironmental implications.

Smith, A.D., Du, S. and Kurien, A. (2023). Vision transformers for anomaly detection and localisation in leather surface defect classification based on low-resolution images and a small dataset. *Applied Science* 13: 8716.

Abstract: Genuine leather manufacturing is a multibillion-dollar industry that processes animal hides from varying types of animals such as sheep, alligator, goat, ostrich, crocodile, and cow. Due to the industry's immense scale, there may be numerous unavoidable causes of damages, leading to surface defects that occur during both the manufacturing process and the bovine's own lifespan. Owing to the heterogeneous and manifold nature of leather surface characteristics, great difficulties can arise during the visual inspection of raw materials by human inspectors. To mitigate the industry's challenges in the quality control process, this paper proposes the application of a modern vision transformer (ViT) architecture for the purposes of low-resolution image-based anomaly detection for defect localisation as a means of leather surface defect classification. Utilising the low-resolution defective and non-defective images found in the open-source Leather Defect detection and Classification dataset and higher-resolution MVTec AD anomaly benchmarking dataset, three configurations of the vision transformer and three deep learning (DL) knowledge transfer methods are compared in terms of performance metrics as well as in leather defect classification and anomaly localisation. Experiments show the proposed ViT method outperforms the light-weight state-of-the-art methods in the field in the aspect of classification accuracy. Besides the classification, the low computation load and low requirements for image resolution and size of training samples are also advantages of the proposed method.

Castillo Rodríguez, N. (2023). Evaluación genética preliminar de poblaciones *in situ* del Caimán Llanero (*Crocodylus intermedius*) en la Orinoquía colombiana. MSc thesis, Universidad Nacional de Colombia, Bogota, Colombia.

Abstract: The Orinoco Crocodile (*Crocodylus intermedius*) is critically endangered due to the indiscriminate hunting it suffered during the last century to satisfy the American and European leather demand. Therefore, today it is represented by isolated individuals, few remaining groups, and to a large extent, *ex situ* populations established for conservation purposes in Colombia and Venezuela. Likewise, legislation and state conservation plans have been developed, which, in the case of Colombia, have suggested the evaluation of the *in situ* genetic status of the species, seeking to preserve its evolutionary potential. The present investigation was developed aiming baseline information to propose concrete and effective actions towards the species conservation. In the first chapter, we re-evaluated the approach made using mitochondrial DNA fragments that suggested managing the species as a single genetic unit. To do this, we used variable molecular markers (microsatellites and the control region of mitochondria). As a result, we identified three genetic groups with geographic correspondence in the Colombian Orinoquía: i) Eastern Meta River Basin, ii) Western Meta and Vichada River Basins, and iii) Guaviare River Basin. Furthermore, we estimated aspects such as gene flow, propose hypotheses that may explain its structure, and performed the assignment of seized individuals whose origin was unknown. In the second chapter, we achieved the genetic characterization of the population that inhabits the Cravo Norte-Ele-Lipa River System and the egg ranching program for conservation purposes that is being locally developed. We identified the population as a valuable resource for the conservation of the species and evaluated historical and present demographic aspects, among which its low effective population size stands out. Finally, in each chapter we propose concrete actions for the conservation and management of the species in Colombia.

Venczel, M. (2023). Updating the fossil record of the alligatoroid crocodylian *Diplocynodon* from the late Eocene of Transylvanian Basin. *Frontiers in Amphibian and Reptile Science* 1 (doi: 10.3389/famrs.2023.1217025).

Abstract: The basal alligatoroid crocodylian *Diplocynodon kochi* Venczel & Codrea, 2022 erected for incomplete trithree-dimensional skull from the late Eocene (Priabonian) Cluj Limestone Formation in Romania, represents one of the easternmost distributed European members of Diplocynodontidae. New isolated cranial and postcranial remains provide new insights into the diagnostic features, phylogenetic relationships and lifestyle of this taxon, extending its fossil record to four new localities situated on the north-western side of the Transylvanian Basin. Diagnostic traits of the holotype include an extended insertion surface of jaw adductors on the parietal and squamosal, whereas the newly referred mandibles possess an enlarged and procumbent first dentary tooth, and the posterior teeth and alveoli are mediolaterally compressed. These attributes might have been related to the prey capture approach of *D. kochi*, involved undoubtedly in the food chains of both continental (fluvial or marshy-lacustrine) and shallow marine environments, as indicated by the taphonomic settings of the surveyed fossil bearing deposits. The warm and humid climate is indicated for the late Eocene (Priabonian) of the Transylvanian Basin based on palynomorphs, however, the presence of "growth rings" and "lines of arrested growth" on the prezygapophyses of a dorsal vertebra referred to *D. kochi*, points to a seasonal climate, installed well before the Eocene-Oligocene terminal event. Positioned between western and eastern European faunas, the diplocynodontid populations from the Transylvanian Basin survived probably the Eocene-Oligocene transition, as suggested by the early Oligocene (Rupelian) fossil record from the area.

Morris, A.W., Smith, I., Chakrabarti, S., Lala, F., Nyaga, S. and Bump, J.K. (2023). Eating an elephant, one bite at a time: Predator interactions at carrion bonanzas. *Food Webs* 37 (<https://doi.org/10.1016/j.fooweb.2023.e00304>).

Abstract: Resource specific competition between predators has typically been studied from their interactions at meso-herbivore carcasses, because such carcasses are abundant. Mega-carcasses like those of elephants are rare but unparalleled in the extent of carrion biomass they offer and the long durations they can persist. These rare resource bonanzas can thus provide unique opportunities to understand sympatric species interactions within likely relaxed competitive scenarios. Using remote cameras that were operational 24-h a day, we monitored two elephant carcasses in Tsavo, Kenya, from when they were discovered until they were completely consumed or became inaccessible. While we found high temporal overlaps in activity patterns between all predators, the terrestrial predator guild (lion/leopard/spotted hyena) was not observed to feed simultaneously, suggesting strong interference competition. Based on photo-analysis and video-evidence of exclusion from a carcass, interference competition within the terrestrial predator guild favored lions over hyenas, and hyenas over leopards. The carcass at the terrestrial-aquatic interface showed more simultaneous feeding bouts between predators (crocodile/spotted hyena), indicating either facilitation and/or higher coexistence between predators that typically occupy different niches. We also observed a hippopotamus scavenging from an elephant carcass, thereby documenting a rare instance of a megaherbivore feeding on a megaherbivore. Our results highlight the importance of monitoring such carcasses through remote cameras, which can significantly add to our existing understanding of food webs and carrion ecology.

Mahana, A. and Choudhury, N. (2023). Biodiversity of reptiles and their conservation strategies in Bhitarkanika National Park, Odisha. *Journal of Emerging Technologies and Innovative Research* 10(7): h225-h237.

Abstract: Protected areas are the major sites of species diversity. Odisha is considered as a unique place with its biogeographic location which supports wide diversity of flora and fauna. To conserve and sustainably use the fragile natural resources, the Odisha State Government has created 19 wildlife sanctuaries, one national park, one biosphere reserve, and two Tiger Reserves in the entire state. Our study area was Bhitarkanika National Park, which is well known for its salt water crocodiles. The study is focused on the diversity of the reptilian species such as *Crocodylus porosus*, *Crocodylus niloticus*, *Crocodylus acutus*, *Python molurus*, *Naja naja*, *Bungarus fasciatus*, *Craspedocephalus gramineus*, etc. Among these, some are facing the risk of extinction and some vulnerable due to anthropogenic activity and natural causes. So, the conservational strategies were discussed in this article to maintain a healthy ecosystem wide species diversity.

Srisuksai, K., Parunyakul, K., Santativongchai, P., Ampawong, S., Tulayakul, P. and Fungfuang, W. (2023). Effect of crocodile oil (*Crocodylus siamensis*) on brain mitochondrial protein expression and cognition in male rats. *Sains Malaysiana* 52(6): 1821-1833.

Abstract: Crocodile oil (CO) is rich in polyunsaturated (PUFAs) fatty acids. Diets rich in PUFAs can maintain mitochondrial function, which is important in signal transduction and survival of neuronal cells. We investigated the effects of CO on brain mitochondrial protein expression and cognitive function in male rats. Twenty-one rats were randomly divided into three groups: (1) control, (2) treated with CO (3 mL/kg), and (3) treated with palm oil (PO; 3 mL/kg). Animals received oral gavage once-daily for 7 weeks. The parameters that were measured were food intake, energy intake, body weight, serum lipid profiles, cognitive behavior, brain mitochondrial architecture, brain mitochondrial expression, and hippocampal structure. In CO and PO groups, food intake decreased significantly

compared with that in the control group ($p < 0.05$), but energy intake, body weight, and lipid profiles were not affected. Spatial learning in the PO group decreased significantly compared with that in control and CO groups ($p < 0.05$). Crocodile oil significantly decreased the percentage of abnormal mitochondria ($p < 0.05$) and the expression of apoptotic marker ($p < 0.05$) compared with those in the PO treatment but also increased energy production marker ($p < 0.05$) compared with those in the control and PO treatment. Moreover, percentage of intact hippocampal cells was not different between CO and control groups, but neuronal cells were lost in the PO group ($p < 0.05$). This study suggest that CO could enhance the brain energy production and maintain cognitive function. CO can be an alternative dietary oil for treating brain energy disorder in the future.

De Araújo Sena, M.V. and Cubo, J. (2023). Inferring the lifestyles of extinct Crocodyliformes using osteoderm ornamentation. *Naturwissenschaften* 110(5) ([doi: 10.1007/s00114-023-01871-8](https://doi.org/10.1007/s00114-023-01871-8)).

Abstract: Osteoderms are bony plates formed within the dermis of diverse vertebrate groups. They are present in all crocodylomorphs but Metriorhynchidae. Most of them show typical bone ornamentation consisting of pits and ridges on their outer surface. The most widely discussed functional hypothesis suggests that the ornamentation of osteoderms influences heat exchange with the environment through the adjacent vascular network, facilitating the absorption of solar radiation. This process allows semiaquatic crocodiles to compensate for heat loss resulting from the high thermal conductivity of surrounding water. In order to test this assertion, we conducted a phylogenetic logistic regression analysis to evaluate the relationship between osteoderm relative area of pits (RAP) and lifestyle (terrestrial versus aquatic) in a sample of crocodyliforms. Our results revealed that lifestyle is significantly explained by RAP: the lower the degree of ornamentation (RAP), the higher the probability of a terrestrial lifestyle. We used this model to infer the lifestyle of two extinct taxa, *Peirosaurus torminni* and *Microsuchus schilleri*. We concluded that terrestrial notosuchians may have lost osteoderm ornamentation due to the lower thermal conductivity of air and reduced heat loss in a terrestrial environment compared to what happens in water. Among these notosuchians, we hypothesize that large terrestrial baurusuchids maintained a stable body temperature due to thermal inertia, whereas small notosuchians took advantage of the early morning sun exposure to warm up and stayed in terrestrial burrows during periods of intense solar radiation. Finally, unlike the almost motionless behavior of freshwater crocodiles, fully marine Metriorhynchidae probably lost osteoderms because they constantly swim, generating heat by muscular contraction, so osteoderms with a thermoregulatory function for heat absorption were no longer positively selected.

Zhang, C., Zhang, R., Ji, C., Pei, Z., Fu, Z., Sang, S., Hao, R. and Zghang, Q. (2023). Bioinspired crocodile skin-based flexible piezoelectric sensor for three-dimensional force detection. *IEEE Sensors Journal* ([doi: 10.1109/JSEN.2023.3301014](https://doi.org/10.1109/JSEN.2023.3301014)).

Abstract: The demand for flexible pressure sensors is increasing with the rapid development of wearable smart devices, dexterous manipulators, and human-machine application interfaces. Despite the development of flexible sensors capable of effectively sensing multidimensional forces, the challenge of directly restoring information from objects in contact remains significant. Inspired by the tactile sensory organ of crocodile skin, this study reports a three-dimensional force sensing sensor, mainly composed of barium titanate Polyvinylidene difluoride and silicone, to form a piezoelectric elastomer layer. Under normal and shear loads, the sensing mechanism relies on the change in output voltage between the semi-spherical electrodes and the piezo elastomer. An interlocking structure detects different directions of shear force. The sensor exhibits excellent directional resolution, with a normal force sensitivity of $20.42 \pm 2 \text{ mV N}^{-1}$ in the pressure range of 0.1N-1.5N, and directional sensing sensitivity of 4.40 mV N^{-1} , 5.29 mV N^{-1} , 4.44

mVN⁻¹, and 4.84 mVN⁻¹ for the four faces, respectively. The sensor also exhibits high linearity. Further demonstrations included testing the sensor in molds over various rough surfaces. The sensor provided timely feedback to distinguish between different surface roughnesses and force directions - expected to be a self-powered wearable device for future human-computer interaction or personalized identification applications.

Simakani, A., Mashapa, C., Muboko, N., Mutanga, C.N. and Gandiwa, E. (2023). Trends and local perceptions of human-crocodile conflicts in Kariba town, northern Zimbabwe. *Human Dimensions of Wildlife* (<https://doi.org/10.1080/10871209.2023.2243970>).

Abstract: This study assessed the nature and local people's perceptions of human-crocodile (*Crocodylus niloticus*) conflicts (HCCs) for the period 2007 to 2016 in Kariba town, northern Zimbabwe. A mixed-method approach was used with 150 local fish folks interviewed between July and October 2017 through face-to-face interviews and secondary data on HCC were retrieved from the wildlife authority's records. In contrast to the general perception from fish folks that there was an increase in HCC, secondary data analysis showed no significant trends of crocodile attacks on people for the period under study. HCC was mainly driven by fishing activities which exposed people to crocodile attacks. The study concludes that despite the recorded non-increasing trend in HCCs, HCC is a major conservation issue in Kariba town given enhanced human-wildlife interactions due to the economic needs for local livelihoods. Community educational programs are recommended as a way to manage HCC and close gaps between the conventional scientific and local knowledge.

Mensah, E.O. (2023). The appropriation of animal names as personal names in Ibibio and Tiv onomastic traditions in Nigeria: An ethnopragmatic study. Pp. 217-237 in *Personal Names and Naming* from an Anthropological-Linguistic Perspective, ed. by S. Ndlovu. Walter de Gruyter GmbH: Berlin.

Adeogun, A.O. and Chukwuka, A.V. (2023). Anthropogenic impacts as determinants of tropical lake morphology: Inferences for strategic conservation of lake wetland biodiversity. In *Science of Lakes - Multidisciplinary Approach*, ed. by A.A. Assani ([doi: 10.5772/intechopen.112274](https://doi.org/10.5772/intechopen.112274)).

Abstract: Lakes as essential ecosystems for diverse life forms, including humans, have suffered altered morphology with adverse effects on biodiversity including amphibians and amphibious species. Thus, it is imperative for effective conservation strategies to simultaneously consider lake morphology, landscape variables, and the role of keystone species as ecosystem engineers for biodiversity preservation. Keystone species, particularly birds and large-bodied predators, ie crocodylians, play a critical role in maintaining the health of lake ecosystems as ecosystem engineers, bringing about large-scale changes in lake morphology and hydrology that determine the abundance and survival of other species in the ecosystem. Conservation strategies should, therefore, prioritize the protection of these keystone species and their habitats. To balance the needs of human society with the protection of lake ecosystems and their biodiversity, conservation practices must involve stakeholder engagement, including government agencies, local communities, traditional ecological knowledge, and scientists. A multidisciplinary approach, incorporating ecological, hydrological, and social factors, is considered necessary for effective lake conservation. This approach will encompass the preservation of lake biodiversity and consider important variables such as lake morphology, landscape variables, and the role of keystone species as ecosystem engineers in providing insights for strategic conservation practices.

Sukjit, S. and Thuwakum, W. (2023). Effect of serum crocodile supplement on glucose and lipid levels in normal weight and overweight subjects with type 2 diabetes mellitus: Pilot study. *Journal of Exercise Physiology Online* 26(4): 19-30.

Abstract: The purpose of this study was to investigate the immediate effects of crocodile serum supplement on the blood glucose level in overweight and normal weight individuals with type 2 diabetes mellitus. Thirty-one patients with an age of 65 ± 9.2 years were randomly divided into 2 Groups that consumed two crocodile serum supplement capsules per day (400 mg.d⁻¹) for 8 weeks. The hematological variables were collected before (baseline) and after 8 weeks to measure blood urea nitrogen, hemoglobin A1C, fasting blood glucose, triglycerides, high-density lipoprotein, and low-density lipoprotein. After 8 weeks, the supplementation with 400 mg serum crocodile resulted in a statistically significant decrease in plasma glucose (P<0.05) in both Groups. Also, the findings suggest that the crocodile serum supplement may have a greater impact on blood glucose levels in the overweight individuals with type 2 diabetes mellitus than their normal weight counterparts. Further research is necessary to validate these findings, and to investigate the long-term effect of crocodile serum supplement consumption on blood glucose levels.

Thévenet, J., Papet, L., Coureaud, G., Boyer, N., Levréro, F., Grimault, N. and Mathevon, N. (2023). Crocodile perception of distress in hominid baby cries. *Proceedings: Biological Sciences* 290(2004) ([doi: 10.1098/rspb.2023.0201](https://doi.org/10.1098/rspb.2023.0201)).

Abstract: It is generally argued that distress vocalizations, a common modality for alerting conspecifics across a wide range of terrestrial vertebrates, share acoustic features that allow heterospecific communication. Yet studies suggest that the acoustic traits used to decode distress may vary between species, leading to decoding errors. Here we found through playback experiments that Nile crocodiles are attracted to infant hominid cries (bonobo, chimpanzee and human), and that the intensity of crocodile response depends critically on a set of specific acoustic features (mainly deterministic chaos, harmonicity and spectral prominences). Our results suggest that crocodiles are sensitive to the degree of distress encoded in the vocalizations of phylogenetically very distant vertebrates. A comparison of these results with those obtained with human subjects confronted with the same stimuli further indicates that crocodiles and humans use different acoustic criteria to assess the distress encoded in infant cries. Interestingly, the acoustic features driving crocodile reaction are likely to be more reliable markers of distress than those used by humans. These results highlight that the acoustic features encoding information in vertebrate sound signals are not necessarily identical across species.

Johnson, J.M., Smaga, C.R., Bock, S.L. and Parrott, B.B. (2023). Maternal provisioning interacts with incubation temperature to affect hatchling mercury exposure in an oviparous reptile. *Biology Letters* 19(8) ([doi: 10.1098/rsbl.2023.0097](https://doi.org/10.1098/rsbl.2023.0097)).

Abstract: The thermal environment experienced by developing embryos can influence the utilization of maternally provisioned resources. Despite being particularly consequential for oviparous ectotherms, these dynamics are largely unexplored within ecotoxicological frameworks. Here, we test if incubation temperature interacts with maternally transferred mercury to affect subsequent body burdens and tissue distributions of mercury in hatchling American alligators (*Alligator mississippiensis*). Nine clutches of alligator eggs were collected from a mercury-contaminated reservoir and incubated at either female- or male-promoting temperatures. Total mercury (THg) concentration was measured in egg yolk collected during incubation and in a suite of tissues collected from hatchlings. THg concentrations in residual yolk and blood were higher in hatchlings incubated at cooler, female-promoting temperatures compared to the warmer, male-promoting

temperatures. THg concentrations in most tissues were positively correlated with THg concentrations in blood and dermis, and egg yolk THg concentration was the best predictor of THg concentration in many resultant tissues. Our results highlight a hereto unknown role of the developmental environment in mediating tissue specific uptake of contaminants in an oviparous reptile.

Godfrey, S.T., Balaguera-Reina, S.A., Metzger III, E.F., Rochford, M.R., Squires, M.A., Gati, E.V., Godahewa, A. and Mazzotti, F.J. (2023). What is the potential for extirpating spectacled caiman from Comprehensive Everglades Restoration Plan projects in South Florida? *Management of Biological Invasions* 14(3): 403-419.

Abstract: Spectacled caimans (*Caiman crocodilus* Linnaeus, 1758) are established invaders in the United States, Cuba, and San Andres Island, Colombia. They have been established in South Florida since the 1970s and are found primarily within Comprehensive Everglades Restoration Plan (CERP) projects. These projects provide suitable habitat and may provide dispersal pathways via water management activities. Caiman presence in these areas directly conflicts with the CERP's goals, and as a generalist species with a broad diet, they can impact biological resources. Past removal efforts failed to extirpate caimans, but their efficacy has not been well evaluated. We addressed caimans via removal surveys during 2012-2021 with the goal of evaluating extirpation or maximum species control within South Florida's CERP projects. Documented opportunistic removals for this study began in December 2012, and systematic efforts have been ongoing since October 2017. We evaluated efficacy of caiman removals by analyzing 10 years of opportunistic and systematic survey data, plus associated removal data, along 11 survey routes during 2012-2021. We also conducted necropsies to collect biological information which could be used to improve removal efforts. We removed 251 caimans during 2012 to 2021, and the rate of caiman removals per year increased from 5 animals during 2012 to a peak of 47 animals during 2020. Necropsies revealed reproductive information (nesting/hatching timelines) that we applied to improve our removal rates. Caiman encounter rates declined from a peak of 1.55 ± 0.66 caiman/hr and 0.72 ± 0.38 caiman/km during 2013 to a low of 0.18 ± 0.09 caiman/hr and 0.03 ± 0.02 caiman/km during 2020 and slightly increased during 2020-2021, likely because of a change in search effort. We evaluated and discussed the potential for extirpating caiman from CERP projects and provide a data-driven prescription for removal efforts.

Gunnin, D. (2023). Femoral Osteohistology in American Alligators (*Alligator mississippiensis*) Reveals High Variation in Growth and Facilitates Interpretation of an Early Pliocene Alligator. MSc thesis, East Tennessee State University, Tennessee, USA.

Abstract: Histological analysis of long bone thin sections is commonly used to infer growth rates and ecology of extinct vertebrates, particularly within Archosauria. However, most comparative neontological studies have used small samples of captive individuals, limiting the scope of variation. To fill this gap, 44 femoral thin sections of wild *Alligator mississippiensis* were prepared and analyzed. Comparison of slides revealed that larger individuals from cooler climates tend to show more LAGs compared to southerly *A. mississippiensis* of similar size, however, there is considerable variation. This pronounced variation in wild specimens emphasizes the need to use caution when interpreting paleohistological data with little modern comparative samples. Finally, thin sections of early Pliocene *Alligator* sp. fossils from the Gray Fossil Site (GFS), Washington Co., Tennessee were prepared. The GFS Alligator grew more slowly than *A. mississippiensis* examined and may have reached reproductive maturity at smaller sizes.

Rogers, T.G. (2023). An Analysis of Online Wildlife Trade: A Situational Crime Prevention Approach. PhD thesis, Texas State

University, Texas, USA.

Abstract: The illegal trade of wildlife and wildlife products is valued in the billions of US dollars each year. This trade affects biodiversity, local economies, political corruption, and places wildlife law enforcement in harm's way. Generally, the detection rates of wildlife trade are assumed to be low. Issues of categorization and enforcement inhibit detection efforts. The Internet contributes to low detection rates by removing a human point in the sale chain, as it connects collectors with buyers directly. Online wildlife trade is not well represented in US-based research. This dissertation contributes to the existing evidence base by providing information regarding trade into the USA using both official seizure data and online advertisement data, and by suggesting means by which preventive intervention may be implemented. Seizure data from 2000-2018 provided by the United States Fish and Wildlife Service was used to identify products encountered most often - "hot products." These hot products were systematically searched in Google, Bing, DuckDuckGo, Etsy, and eBay, with advertisements indexed. An exhaustive descriptive analysis was performed on both the official seizure data and the online advertisements. The online ads were also subjected to a script analysis (Cornish 1994) of the shipping techniques used by online wildlife traders to deconstruct the process and aid in developing points for potential intervention. The findings from this study present a novel understanding of how the open and deep webs are used to trade wildlife. This study serves as a foundation for further research examining successful points for intervention.

Ito, K., Kinugasa, T., Chiba, K., Okuda, Y., Takasaki, R., Hida, S., Okoshi, T., Hayashi, R., Yoshida, K. and Osuka, K. (2023). The robotic approach to the passive interlocking mechanism in the hindlimb musculoskeletal system of *Crocodylus porosus*. *Advanced Robotics* (<https://doi.org/10.1080/01691864.2023.2256375>).

Abstract: Efficient locomotion in terrestrial vertebrates relies on intra-limb coordination that emerges through interaction with the environment and passive interlocking of the musculoskeletal system. These structures have been well investigated in some mammals and birds, but the presence of similar structures. This study addresses the functionality of the passive interlocking system in reptilian hindlimb locomotion by dissecting *Crocodylus porosus* and constructing a robot. Based on the dissection, we hypothesized that the passive interlocking mechanism consisted of multiple muscles to maintain the semi-erect limb posture and support its weight. The mechanism is provided by the caudifemoralis longus muscle, along with its tendon and the gastrocnemius externus, acting as a passive element that interacts with the ground reaction force. Accordingly, the feasibility of the interlocking function was demonstrated by a robot implementing the hindlimb and pelvic musculoskeletal system of crocodilians. This study provides new insights into the locomotion mechanism of crocodilians and emphasizes the importance of passive interlocking in efficient locomotion in terrestrial vertebrates. The findings could have implications for developing biomimetic robots and understanding the evolution of terrestrial locomotion in vertebrates.

Ito, K., Hida, S., Kinugasa, T., Okuda, Y., Chiba, K., Takasaki, R. and Osuka, K. (2022). Crocodilian knee locking mechanism and intralimb coordination of a hindlimb in the stance phase during high walking - investigation based on the dissection of *Crocodylus porosus* and a physical model. No. 22-2 in *Proceedings of the 2022 JSME Conference on Robotics and Mechatronics*, Sapporo, Japan, 1-4 June 2022.

Abstract: The limb musculoskeletal anatomy and its function during walking in crocodilians have been well studied, but the walking mechanism derived from mechanical behaviors of components within the limb musculoskeletal systems has been less addressed. This study focuses on the knee locking mechanism during high

walking of crocodilians through dissections of a *Crocodylus porosus* hindlimb and a physical model generated based on the dissected individual. The data from the dissection suggest that the crocodilian hindlimb musculoskeletal system has a function to maintain a stance posture by constraining the knee joint with the tension generated by the caudofemoralis longus and ground reaction force. A test using a physical model supported the feasibility of this knee locking function.

Moncada-Jimenez, J.F., Hernandez-Gonzalez, F., Prada-Quiroga, C.F., Garcia-Calderon, L.M., Garcia, Y., Hernandez, E., Lopez, A., Argel, A., Polo, J.M., Farfan-Ardila, N. and Balaguera-Reina, S.A. (2023). Phylogeography of the American crocodile, *Crocodylus acutus* (Crocodylia: Crocodylidae) in Colombia: a conservation perspective. *Biological Journal of the Linnean Society* (<https://doi.org/10.1093/biolinnean/blad073>).

Abstract: *Crocodylus acutus* is the most widely distributed crocodile in the Neotropics, playing a key role in the ecosystems it inhabits. However, unsustainable use and habitat degradation have depleted its populations across its range. In Colombia, it is classified as Endangered by local authorities, and a legislative framework for its protection has been created, implementing hunting bans and breeding programmes. Successful implementation of these programmes depends on the existence of baseline genetic information, which is currently insufficient for the species. We assess the genetic diversity, phylogeography, and demographic patterns of the American crocodile in Colombia based on three mitochondrial markers (*cox1*, *cytb*, and *trnP/trnF/D-Loop*) and propose actions for its management and conservation. We processed 33 American crocodile samples from both wild and captive populations and performed genetic variability, phylogenetic, phylogeographical, and neutrality tests, including previously reported sequences. We found evidence of high genetic variability in Colombia, the existence of clearly differentiated mitochondrial phylogenetic clades, and possible human-influenced or stochastic demographic variation events. We propose guidelines for the translocation of American crocodiles based on our findings and present evidence of possible dispersal events in the Caribbean and Magdalena regions. Finally, we suggest the implementation of management units and identify research priorities for future work.

Ferreira Romão, M. and Quagliatto Santos, A.L. (2023). Muscular anatomy of the thorax and thoracic limb of *Caiman crocodilus* (Linnaeus, 1758) (Crocodylia: Alligatoridae) by means of digital dissection and three-dimensional models. *Brazilian Journal of Implantology and Health Sciences* 5(4): 453-470.

Abstract: The *Caiman crocodilus*, popularly known as alligator, is a species of crocodilian, which has a crest or “forehead” described as “in crescent shape”, observed immediately dorsal in relation to the eyes, as well as above the dorsal region of the snout, with an ossified crust rostral to the orbicular region. The present study aimed to describe the muscular anatomy of the thorax with emphasis on the thoracoappendicular muscles, and *Caiman crocodilus* thoracic limb, with the aid of X-ray (RX), ultrasonography (US), and detailed manual dissection; identified the thickness of the muscle groups of the thorax and thoracic limb of the *Caiman crocodilus*, through ultrasonography, and, at the end, three-dimensional models of the muscular anatomy of the thorax were built, with emphasis on the thoracoappendicular muscles, and the thoracic limb of the *Caiman crocodilus*, with finalization in three-dimensional PDF. Anatomical descriptions have greatly favored interventions in wild animals, as well as the use of imaging tests such as X-ray and US. In addition, 3D schematic models clarify topographical relationships and highlight muscle depth, for example. In this way, it is possible to identify anatomical differences and intervene in case of diagnoses and prognoses, such as in US, even in real time.

Hogan, J.D. (2023). The egg-thief architect: experimental

oviraptorosaur nesting physiology, the possibility of adult-mediated incubation, and the feasibility of indirect contact incubation. *Paleobiology* (<https://doi.org/10.1017/pab.2023.19>).

Abstract: Numerous, high-quality reproduction-related oviraptorosaur fossils have been described. However, oviraptorosaur-style nests are unknown among extant animals, and their curious construction makes nesting behavior difficult to interpret. Experiments were undertaken to better understand oviraptorosaur nesting strategies. A surrogate was constructed and placed atop mock-oviraptorosaur nests built from sand and 36 infertile emu eggs (as *Macrololithus* approximations) arranged according to the most current nest reconstructions. Thermometers, placed within each egg and throughout the experimental area, recorded energy flow from the surrogate dinosaur into the nesting microenvironment. One experiment examined a basic open nest warmed from above; the second, a fully buried clutch warmed from above; and the third, a nest open like the first but with heating elements (representing hindlimbs) extending down into the nest. It was found that egg temperatures in each scenario surpassed ambient temperatures without requiring excessive energy input. Final clutch temperatures were below most avian values, closer to crocodilian incubation, but are likely conservative, considering experimental parameters. These results may support the idea that an oviraptorosaur could use adult-generated energy to warm a clutch above ambient conditions. Additionally, egg tiers would be warmer and more uniform in temperature if heated by elements within the nest, such as hindlimbs, instead of solely from above. Results from the second experiment indicate that an endothermic adult could possibly warm a clutch fully buried beneath itself despite a barrier. Although not likely a behavior exhibited by oviraptorosaurs, such results suggest an important evolutionary step bridging guarded subterranean eggs and contact-incubated subaerial eggs.

Young, M.T., Zverkov, N.G., Arkhangelsky, M.S., Ippolitov, A.P., Meleshin, I.A., Mirantsev, G.V., Shmakov, A.S. and Stenshin, I.M. (2023). Thalattosuchian crocodylomorphs from European Russia, and new insights into metriorhynchid tooth serration evolution and their palaeolatitudinal distribution. *PeerJ* 11: e15781.

Abstract: From the Middle Jurassic to the Early Cretaceous, metriorhynchid crocodylomorphs inhabited marine ecosystems across the European archipelago. Unfortunately, European metriorhynchids are only well known from Germany, France, and the UK, with the Eastern European fossil record being especially poor. This hinders our understanding of metriorhynchid biodiversity across these continuous seaways, and our ability to investigate provincialism. Here we describe eleven isolated tooth crowns and six vertebrae referable to Metriorhynchidae from the Callovian, Oxfordian, Volgian (Tithonian), and Ryazanian (Berriasian) or Valanginian of European Russia. We also describe an indeterminate thalattosuchian tooth from the lower Bajocian of the Volgograd Oblast, the first discovery of a marine reptile from the Bajocian strata of European Russia. These rare fossils, along with previous reports of Russian thalattosuchians, indicate that thalattosuchians have been common in the Middle Russian Sea since it was formed. Palaeolatitude calculations for worldwide metriorhynchid-bearing localities demonstrate that the occurrences in European Russia are the most northern, located mainly between 44-50° north. However, metriorhynchids appear to be rare at these palaeolatitudes, and are absent from palaeolatitudes higher than 50°. These observations support the hypothesis that metriorhynchids evolved an elevated metabolism but were not endo-homeothermic, especially as endo-homeothermic marine reptiles (ichthyosaurs and plesiosaurs) remained abundant at much higher palaeolatitudes.

Halaçlar, K., Rummy, P., Liu, J., Hunt, A.P., Van Do, T., Minh, N.T. and Deng, T. (2023). Exceptionally well-preserved crocodilian coprolites from the Late Eocene of Northern Vietnam: Ichnology and paleoecological significance. *ISCIENCE* (doi: <https://doi.org/10.1016/j.isci.2023.105444>).

Abstract: This study examines 55 coprolites from the Na Duong Basin to reconstruct the paleoenvironment. Coproecology sheds light on understanding the complex prey-predator relationships, trophic dynamics, and ecosystem evolution. Through quantitative and multidisciplinary analysis, the putative coprolites were attributed to crocodilian producers, leading to the establishment of a new ichnogenus and species, *Crococopros naduongensis* igen. et isp. nov., based on distinct characteristics and comparisons. The study provides compelling evidence of an ancient river or lake-like environment dominated by diverse crocodilian fauna, indicating a thriving food chain in the Na Duong Basin. The findings also highlight the remarkable richness of ichnofauna, fauna, flora, and the presence of a favorable climate, confirming the area as a significant fossil Lagerstätte in Southeast Asia. Overall, this study offers a unique snapshot of the past, providing valuable insights into the regional ecosystem and significantly contributing to our understanding of paleoenvironmental conditions and biotic interactions.

Staniewicz, A., McCabe, G. and Holderied, M. (2023). The low-frequency vocal repertoire of adult African dwarf crocodiles. *African Journal of Herpetology* (<https://doi.org/10.1080/21564574.2023.2237035>).

Abstract: Acoustic techniques are rapidly becoming powerful tools for species monitoring and biodiversity assessment. These methods can be particularly appropriate for forest-dwelling crocodiles which are difficult to survey visually. However, basic vocal-repertoire data is lacking for many of the poorly known species. Here, we used passive acoustic recorders to capture 97 spontaneous vocal signals from a pair of captive adult African dwarf crocodiles (*Osteolaemus tetraspis*). We catalogued their acoustic repertoire and compared the calls recorded in captivity with 201 suspected wild *O. tetraspis* calls recorded in Gabon to determine whether the wild calls belonged to the same species. Captive and wild crocodiles produced the same four types of calls, not previously identified in other crocodylids. Short, low-frequency “drums” (31 ± 12 Hz), longer, low-frequency “rumbles” (40 ± 14 Hz), as well as higher frequency “moos” (299 ± 133 Hz) and “gusts” (219 ± 108 Hz). Our results provide reference for species identification and support implementation of acoustic-based methods for African dwarf crocodile monitoring and conservation assessment. The data can further contribute to landscape-wide biodiversity monitoring and counter-poaching activities, as well as improving our understanding of crocodilian ecology and behaviour.

Sohlén, W. (2023). Morphological Characterization of the Muscular Ridge in Non-Crocodilian Reptiles. BSc thesis, Linköping University, Linköping, Sweden.

Abstract: The cardiovascular systems in ectothermic reptiles have long been studied and its development represent a transition state between a single- and a double circulation. This literature review focus on the typical-reptilian heart and therefore distinguishes between orders within the class of Reptilia. The typical-reptilian heart is found in the non-crocodilian reptiles referring to the orders Chelonia and Squamata. The heart is composed of two atria and one common ventricle, compartmentalized into three interconnected ventricular cava. However, there is some species-specific variation in gross anatomy where the monitor lizard *Varanus* and *Python* pose a striking exception to the typical-reptilian heart. The cardiac building plan exhibits variation in size and relative dimensions, in particular the relationship between cava and the degree of ventricular septation. *Varanus* and *Python* have a larger and more muscular systemic side of the ventricle, a highly developed vertical septum and muscular ridge. Today, it is known that a ventricle with a less developed muscular ridge acts as a single pressure source, subsequently allowing admixture of oxygenated- and deoxygenated blood within the ventricle. In contrast, a ventricle with a more developed

muscular ridge and vertical septum may function as a dual pressure source during parts of systole, temporarily separating the ventricle in a high-pressure systemic side and a low-pressure pulmonary side. Septal development provides different haemodynamic conditions and yield diverse functions. This literature review is a combination of practical laboratory work and a literature study. Dissections of the typical-reptilian hearts provide information about exterior and interior morphology, and findings are then compared to existing literature.

Spiekman, S.N.F., Fernandez, V., Butler, R., Dollman, K.N. and Maidment, S. (2023). A taxonomic revision and cranial description of *Terrestrisuchus gracilis* (Archosauria, Crocodylomorpha) from the Late Triassic of Pant-y-ffynnon Quarry (southern Wales). *Papers in Palaeontology*.

Abstract: Non-crocodyliform crocodylomorphs, formerly referred to the informal group “Sphenosuchia”, are the earliest known crocodylomorph precursors of extant crocodylians. Therefore, they are crucial for our understanding of early crocodylian evolution and the origin of typical crocodylian characteristics, such as the formation of a secondary palate, complex cranial pneumaticity, and a reinforced braincase. *Terrestrisuchus gracilis*, known from the Late Triassic fissure fill deposits of Pant-y-ffynnon in southern Wales, is represented by almost 200 specimens, comprising articulated, partially associated, and isolated remains. In this contribution, we provide a taxonomic revision of *T. gracilis* and redescribe its cranial anatomy in detail, based in part on novel μ CT data. The posterior skull region is extensively pneumatized as indicated, among other features, by large pre- and postcarotid recesses on the parabasisphenoid and a large pneumatic cavity within the articular of the mandible. In contrast, the quadrate only forms a small, unfused contact with the prootic, suggesting that complex pneumatization of the postorbital region predated the coossification of the quadrate and braincase in Crocodylomorpha. *Terrestrisuchus gracilis* preserves an ossified basihyal, which represents the first occurrence of this bone among non-avemetarsalian archosaurs. Finally, we show that *T. gracilis* was likely cathemeral (ie active in a range of light levels), based on a phylogenetic flexible discriminant analysis (pFDA) of the relative dimensions of the sclerotic ring and orbit.

Bourke, J.M. and Witmer, L.M. (2023). Soft tissues influence nasal airflow in diapsids: Implications for dinosaurs. *Journal of Morphology* 284(9) (doi: 10.1002/jmor.21619).

Abstract: The nasal passage performs multiple functions in amniotes, including olfaction and thermoregulation. These functions would have been present in extinct animals as well. However, fossils preserve only low-resolution versions of the nasal passage due to loss of soft-tissue structures after death. To test the effects of these lower resolution models on interpretations of nasal physiology, we performed a broadly comparative analysis of the nasal passages in extant diapsid representatives, eg alligator, turkey, ostrich, iguana, and a monitor lizard. Using computational fluid dynamics, we simulated airflow through 3D reconstructed models of the different nasal passages and compared these soft-tissue-bounded results to similar analyses of the same airways under the lower-resolution limits imposed by fossilization. Airflow patterns in these bony-bounded airways were more homogeneous and slower flowing than those of their soft-tissue counterparts. These data indicate that bony-bounded airway reconstructions of extinct animal nasal passages are far too conservative and place overly restrictive physiological limitations on extinct species. In spite of the diverse array of nasal passage shapes, distinct similarities in airflow were observed, including consistent areas of nasal passage constriction such as the junction of the olfactory region and main airway. These nasal constrictions can reasonably be inferred to have been present in extinct taxa such as dinosaurs.

Mendonça, W.C.S., Duncan, W.P., Vidal, M.D., Magnusson, W.E. and Da Silveira, R. (2023). Conservation implications of tourism and stress for Amazonian caimans. *The Journal of Wildlife Management* (<https://doi.org/10.1002/jwmg.22482>).

Abstract: Ecotourism is a strategy for biodiversity conservation, but it involves possible negative effects on animal health and welfare. Large predators such as crocodilians are one of the great public attractions sought after for tourist interactions. Interactions with wild animals and humans can hyperstimulate the hypothalamic-pituitary-adrenal axis in the short-term, in the case of crocodilians showing an increased corticosterone level, which is indicative of physiological stress. Between September and December 2019, we simulated interactions between tourists and Amazonian crocodilians at Anavilhanas National Park in Central Amazonia, Brazil to evaluate the effects of handling and use of photographic flashes on Black caiman (*Melanosuchus niger*) and Spectacled caiman (*Caiman crocodilus*) on circulating corticosterone and lactate. Corticosterone levels increased 1.7-fold during handling and 2.7-fold when exposed to photographic flashes in Black caiman but not in Spectacled caiman. Increased corticosterone concentrations in Black caiman were characterized by an increase caused by handling and were more intense after flashes than in controls, but the combination of handling and flash had no effect. During handling in simulated tourist interactions, anaerobic respiration increased lactate in black caiman but not in Spectacled caiman. The effect of simulated tourist interactions with Amazonian crocodilians was dependent on the handling and especially on flash use in Black caiman. The results can assist management, conservation programs, and public policies, especially in programs based on tourism interaction with Amazonian crocodilians.

Gardin, A., Puc  at, E., Garcia, G., Boisserie, J-R., Euriat, A., Joachimski, M.M., Nutz, A., Schuster, M. and Otero, O. (2023). Stable oxygen isotopes of crocodilian tooth enamel allow tracking Plio-Pleistocene evolution of freshwater environments and climate in the Shungura Formation (Turkana Depression, Ethiopia). *Biogeosciences* (<https://doi.org/10.5194/bg-2023-125>).

Abstract: This study adopts a new approach describing paleohydrology and paleoclimates based on the interpretation of stable oxygen isotopes ($\delta^{18}\text{O}_p$) recorded in fossil crocodilian teeth. They represent an archive of prime interest for tracking freshwater paleoenvironmental change, applicable for many paleontological localities in the world: crocodilian teeth are abundant in continental basins and widely distributed since their diversification during the Mesozoic; the enamel phosphate is resistant to diagenesis and retains its original isotopic composition over geological timescales; their $\delta^{18}\text{O}$ mainly relies on that of the crocodilian's home water body ($\delta^{18}\text{O}_w$), which in turn reflects water body types, regional climate, and evaporation conditions. This study presents the first application of this interpretative model to the Shungura Formation (Lower Omo Valley, Ethiopia), a key witness of the important environmental changes in eastern Africa during the Plio-Pleistocene that impacted the evolution of regional faunas, including humans. In this complex and variable environmental context, the $\delta^{18}\text{O}_p$ of coexisting crocodilians allows for fingerprinting the diversity of aquatic environments they had access to at a local scale. Like previous geochemical studies performed on paleosols and bivalves in this area, our data indicate a marked increase in $\delta^{18}\text{O}_w$ between 2.97 Ma and ca. 1.14 Ma, probably resulting from the joint effect of the migration of the air streams convergence zones between the West African and Indian Summer Monsoons and of the decrease in rainfall amounts above the Ethiopian Highlands. Contrary to some conclusions based on terrestrial proxies, the $\delta^{18}\text{O}_p$ of crocodilian teeth does highlight any major change affecting aquatic environments, rather pointing to stability of these environments between 2.97 Ma and ca. 2.57 Ma. By contrast, the diversity of aquatic environments accessible to crocodilians seems to be restricted in most analysed stratigraphical units after ca. 2.3230 Ma, a feature that may reflect more arid conditions in the Turkana Depression.

Formoso, K.K., Habib, M.B. and V  lez-Juarbe, J. (2023). The role of locomotor ancestry on secondarily aquatic transitions. *Integrative and Comparative Biology* (<https://doi.org/10.1093/icb/icad112>).

Abstract: Land-to-sea evolutionary transitions are great transformations where terrestrial amniote clades returned to aquatic environments. These secondarily aquatic amniote clades include charismatic marine mammal and marine reptile groups, as well as countless semi-aquatic forms that modified their terrestrial locomotor anatomy to varying degrees to be suited for swimming via axial and/or appendicular propulsion. The terrestrial ancestors of secondarily aquatic groups would have started off swimming strikingly differently from one another given their evolutionary histories as inferred by the way modern terrestrial amniotes swim. With such stark locomotor functional differences between reptiles and mammals, we ask if this impacted these transitions. Axial propulsion appears favored by aquatic descendants of terrestrially sprawling quadrupedal reptiles, with exceptions. Appendicular propulsion is more prevalent across the aquatic descendants of ancestrally parasagittal postured mammals, particularly early transitioning forms. Ancestral terrestrial anatomical differences that precede secondarily aquatic invasions between mammals and reptiles, as well as the distribution of axial and appendicular swimming in secondarily aquatic clades, may indicate that ancestral terrestrial locomotor anatomy played a role, potentially in both constraint and facilitation, of certain aquatic locomotion styles. This perspective of the land-to-sea transition can lead to new avenues of functional, biomechanical, and developmental study of secondarily aquatic transitions.

Crossley, J.L., Smith, B., Tull, M., Elsey, R.M., Wang, T. and Crossley II, D.A. (2023). Hypoxic incubation at 50% of atmospheric levels shifts the cardiovascular response to acute hypoxia in American alligators, *Alligator mississippiensis*. *Journal of Comparative Physiology B* (doi: [10.1007/s00360-023-01510-8](https://doi.org/10.1007/s00360-023-01510-8)).

Abstract: We designed a series of studies to investigate whether hypoxia (10% O_2) from 20% of incubation to hatching, or from 20 to 50% of incubation, affects cardiovascular function when juvenile American alligators reached an age of 4-5 years compared to juveniles that were incubated in 21% O_2 . At this age, we measured blood flows in all the major arteries as well as heart rate, blood pressure, and blood gases in animals in normoxia and acute hypoxia (10% O_2 and 5% O_2). In all three groups, exposure to acute hypoxia of 10% O_2 caused a decrease in blood O_2 concentration and an increase in heart rate in 4-5-year-old animals, with limited effects on blood flow in the major outflow vessels of the heart. In response to more acute hypoxia (5% O_2), where blood O_2 concentration decreased even further, we measured increased heart rate and blood flow in the right aorta, subclavian artery, carotid artery, and pulmonary artery; however, blood flow in the left aorta either decreased or did not change. Embryonic exposure to hypoxia increased the threshold for eliciting an increase in heart rate indicative of a decrease in sensitivity. Alligators that had been incubated in hypoxia also had higher arterial PCO_2 values in normoxia, suggesting a reduction in ventilation relative to metabolism.

Myburgh, A., Myburgh, J., Steyl, J., Downs, C.T., Botha, H., Robinson, L. and Woodborne, S. (2023). The histology and growth rate of Nile crocodile (*Crocodylus niloticus*) claws. *Journal of Morphology* 284(10) (doi: [10.1002/jmor.21634](https://doi.org/10.1002/jmor.21634)).

Abstract: The histology and growth of reptilian and crocodilian claws (ungues) have been extensively studied; however, Nile crocodile (*Crocodylus niloticus*) claws have not received adequate attention. Furthermore, age estimations for reptilian claws remain unexplored, despite Nile crocodile claws being used in long-term dietary reconstruction studies, assuming certain age-related patterns. In this study, we investigate the histology and growth patterns of Nile crocodile claws, aiming to infer axes for sampling cornified material

for radiocarbon dating and establish age estimations for crocodilian claws. Our findings reveal that Nile crocodile claws exhibit growth patterns similar to other reptilians, presenting as modified scutes/scales with an age profile along the sagittal plane. This profile starts at the basal germ matrix and progressively expands in thickness and age dorsoventrally towards the apex or “tip.” Consequently, the oldest corneous material is concentrated at the most dorsal point of the claw’s apex. To validate previous dietary reconstruction assumptions, we conducted radiocarbon dating on this region of the claw, which supported the idea that retained corneous material in the claws is typically relatively young (5-10 years old) due to abrasion. Our study contributes insights into the histology and growth dynamics of Nile crocodile claws, shedding light on their use in dietary reconstruction studies and emphasizing the significance of considering age-related assumptions in such investigations.

Chavan, U.M. and Borkar, M.R. (2023). Observations on cooperative fishing, use of bait for hunting, propensity for marigold flowers and sentient behaviour in Mugger crocodiles *Crocodylus palustris* (Lesson, 1831) of river Savitri at Mahad, Maharashtra, India. *Journal of Threatened Taxa* 15(8): 23750-23762.

Abstract: As far as animal cognition is concerned, in comparison with mammals and birds, reptiles have been underestimated and research in reptilian cognition hasn’t progressed much due to this bias. Though crocodiles are generally stereotyped as lethargic and lacking social interactions except for territoriality, parental care and prey ambush, they demonstrate discrete behavioural repertoire in a variety of situations suggestive of refined cognition. The observations presented here were recorded during a long-term study on Muggers *Crocodylus palustris* of Savitri River in Maharashtra, and indicate social behaviour of remarkable acuity among Muggers to optimize foraging, which clearly hints at cooperative fishing. Also, on many occasions here, the Muggers were seen to have sticks on their snouts or lay still in the vicinity of floating twigs presumably to lure birds that desperately scouted for nesting material; though only on one occasion the unsuspecting bird was ambushed successfully. Flight initiation distances (FID) of birds that forage and nest in crocodilian habitat have been measured to assess their wariness towards crocodile’s presence. We report the attraction of free ranging Muggers here to the yellow Marigold *Tagetes erecta* flowers. We also remark on apparent sentience involving a dog that was chased into the river by a pack of feral dogs, the ‘aquatic refugee’ having been seemingly nudged and escorted to safety of the bank by crocodiles. All these behaviours are discussed in the light of previous reports involving other crocodilian species elsewhere, to assess the cognitive faculty of this species.

Smaga, C., Bock, S., Johnson, J., Rainwater, T., Singh, R., Deem, V., Letter, A., Brunell, A. and Parrott, B. (2023). The influence of incubation temperature on offspring traits varies across northern and southern populations of the American alligator (*Alligator mississippiensis*). *Authorea* (doi: [10.22541/au.169259410.03550777/v1](https://doi.org/10.22541/au.169259410.03550777/v1)).

Abstract: Maternal provisioning and the developmental environment are fundamental determinants of offspring traits, particularly in oviparous species. However, the extent to which embryonic responses to these factors differ across populations to drive phenotypic variation is not well understood. Here, we examine the contributions of maternal provisioning and incubation temperature to variation in hatchling morphological and metabolic traits across four populations of the American alligator (*Alligator mississippiensis*), encompassing a large portion of the species’ latitudinal range. Our results show that whereas the influence of egg mass is generally consistent across populations, responses to incubation temperature show extensive population-level variation in several fitness-related traits, including mass, head length, head width and residual yolk mass. Additionally, the influence of incubation temperature on developmental rate is greater at northern

populations, while the allocation of maternal resources towards fat body mass is greater at southern populations. Overall, our results suggest that responses to incubation temperature, relative to maternal provisioning, are a larger source of interpopulation phenotypic variation and may contribute to the local adaptation of populations.

Valli, F.E., Simoncini, M.S., González, M.A. and Piña, C.I. (2023). How do maternal androgens and estrogens affect sex determination in reptiles with temperature-dependent sex? Development, Growth & Differentiation (doi: [10.1111/dgd.12887](https://doi.org/10.1111/dgd.12887)).

Abstract: Temperature sex determination (TSD) in reptiles has been studied in order to elucidate the mechanisms by which temperature is transformed into a biological signal that determines the sex of the embryo. Temperature is thought to trigger signals that alter gene expression and hormone metabolism, that will determine the development of female or male gonads. In this review we focus on collecting and discussing important and recent information on the role of maternal steroid hormones in sex determination in oviparous reptiles such as crocodiles, turtles and lizards that possess TSD. In particular we focus on maternal androgens and estrogens deposited in the egg yolk and their metabolites which could also influence the sex of offspring. Finally, we suggest guidelines for future research to help clarify the link between maternal steroid hormones and offspring sex.

Voltan, E. (2023). Egyptian fauna in nilotic scenes. Repositorio Institucional de la Universidad de Malaga (<https://riuma.uma.es/xmlui/handle/10630/27397>).

Abstract: The land of Egypt was fought over and incorporated into Rome’s mentality in a similar way to the conquest of Greece: the conquered subjugated the conqueror and, through its culture, bound him to itself in a way that was as subtle as it was indissoluble. In fact, Roman swords and war strategies were disarmed by the knowledge and exotic fascination of the Nilotic land, to the extent that the ferment created by the influence and direct confrontation with this millenary civilisation led to the creation of a peculiar material culture inspired by Egypt through the Roman perspective. An effective proof of this is the elaboration of nilotic landscapes which, from the first testimonies of the late Republican period, became popular in the Imperial period, becoming a real fashion driven by the more intense contacts between Egypt and the Empire, especially with the annexation of the former to the Roman territories. Within the repertoire of Roman Nilotic representations, there are some recurrent iconographic elements that “mark” this figurative typology. In addition to the flora, the representation of the fauna living on the banks of the Egyptian river plays a fundamental role in the iconography of the Roman Nilotic. The aim of this paper is to draw attention to the different types of animals that animate these images, such as crocodiles, hippopotamuses, ibises, etc., their manner of representation, especially between the 1st and 2nd centuries AD, as well as their representation as an abstraction of exoticism, rarity and distance associated with the Roman province of Egypt. Finally, some of the main compositional schemes relating to the encounter/confrontation between the Nilotic fauna and the pygmies, central characters in the Nilotic scenario, will be briefly considered.

He, N. (2023). The origin of the Chinese Dragon: The story of the Chinese spiritual totem. *In* All About Chinese Culture. Springer: Singapore.

Abstract: The coiled dragon painted on the pottery from Taosi adopted the body of the red-banded snake and the head of the mute swan. When it was necessary to show muscles and teeth to the foreign pressure from the west and north, the head of the mute swan was replaced by the head of the crocodile. The coiled dragon of Taosi symbolized an array of concepts including the idea of trying

the peaceful means as the first option before resorting to military forces as the second choice; the principle of subduing the enemy without fight; the principle of hiding the light under a bushel in peace and fighting with unflinching courage in the war; the attachment to the land and the reverence for the ancestors, etc. The coiled dragon of Taosi formed the initial style of the dragon of Central China descending to later dynasties.

Leiva, P.M.L., Labaque, M.C., Piña, C.I. and Simoncini, M.S. (2023). Influence of climatic variables on corporal attributes of adult female caiman and their relationship with reproductive success. *South American Journal of Herpetology* 28(1): 16-25.

Abstract: Studies on crocodilians indicate that energy investment in reproduction is conditioned by prey availability, which is in turn affected by rainfall. Therefore, environmental variables may affect individual body condition (BC) and physiological condition (PC). We evaluated the influence of climatic factors on the BC and PC of wild reproductive female *Caiman latirostris* and their performance in different seasons. We found no relationship between female BC and climatic variables, which indicates that only females that have managed to overcome a minimum required BC can reproduce and suggests that the minimum BC is not fixed. Females with higher BC produced nests with greater hatching success, proving that if there is a minimum energy threshold that triggers reproduction; once the threshold is surpassed the excess energy may be invested in quality of progeny. We observed that as rainfall increases in river headwaters in March-April, clutch size decreases, indicating that in years with lower rainfall, only larger females may reproduce. Regarding PC, muscle fatty acid (FA) indicated C18:2 has a strong association with minimum temperatures in September, suggesting that temperatures of the first warm months determine the availability of food. Also, variation in plasma FA are associated with precipitation in October and December, showing that precipitation influences diet and PC. We conclude that rainfall and minimum ambient temperatures modulate the reproduction of *C. latirostris* and the dynamics of the population as a whole. Also, BC is a useful indicator for evaluating reproductive performance and PC is a useful indicator to evaluate nutritional status of populations.

Estudios en cocodrilianos indican que la energía invertida en reproducción es condicionada por la disponibilidad de presas, el que a su vez es afectado por las precipitaciones. Por lo tanto, variables ambientales podrían afectar la condición corporal (CC) y condición fisiológica (CF) de los individuos. Evaluamos la influencia de los factores climáticos en CC y CF en la reproducción de hembras silvestres de *Caiman latirostris* y su performance en diferentes temporadas. No encontramos relación entre la CC de las hembras y variables climáticas, lo que indica que solo las hembras que alcanzan una CC mínima requerida se reproducirán; lo que sugiere que esta CC mínimo no es fijo. Las hembras con mayor CC produjeron nidos con mayor éxito de eclosión, lo que demuestra que si hay un umbral mínimo de energía que desencadena la reproducción, una vez superado el umbral el exceso de energía puede invertirse en la calidad de la progenie. Observamos que, a medida que aumentan las precipitaciones en las cabeceras de los ríos durante marzo-abril, disminuye el tamaño de las puestas, lo que indica que en los años con menos precipitaciones sólo se reproducen las hembras de mayor tamaño. En cuanto a la CF, el ácido graso (AG) muscular C18:2 tiene una fuerte asociación con las temperaturas mínimas en septiembre, lo que sugiere que las temperaturas de los primeros meses cálidos determinan la disponibilidad de alimento. Además, la variación de los perfiles de AG plasmáticos está asociada a las precipitaciones en octubre y diciembre, lo que demuestra que las precipitaciones influyen en la dieta y la CF. Concluimos que las precipitaciones y las temperaturas mínimas ambientales modulan la reproducción de *C. latirostris* y la dinámica de la población en su conjunto. Además, la CC es un indicador útil para evaluar el rendimiento reproductivo y la CF es un indicador útil para evaluar el estado nutricional de las poblaciones.

Costa Pereira, A., Bielefeld Nardoto, G. and Rinaldi Colli, G. (2023). Sources of intraspecific variation in the isotopic niche of a semi-aquatic predator in a human-modified landscape. *PeerJ* 11: e15915.

Abstract: Intraspecific variation modulates patterns of resource use by species, potentially affecting the structure and stability of food webs. In human-modified landscapes, habitat disturbance modifies trophic interactions and intraspecific niche variation, impacting population persistence. Here, we investigated the relationship of sex, ontogeny, and habitat factors with the trophic niche of *Caiman crocodilus* in an agricultural landscape. We evaluated temporal variation in the trophic niche parameters using carbon and nitrogen stable isotope analysis from different body tissues. We found that caimans exploit the same carbon and nitrogen pools through time, with low isotopic variability between seasons, partly due to the slow isotope turnover rates of tissues in crocodilians. Conversely, the trophic niche of caimans varied across habitats, but with no evidence of a difference between natural and anthropogenic habitats. It apparently results from the influence of habitat suitability, connectivity, and caiman movements during the foraging. Our findings highlight the broader niches of juvenile caimans relative to adults, possibly in response of territorialism and opportunistic foraging strategy. Although using similar resources, females had a larger niche than males, probably associated with foraging strategies during nesting. Considering the sex and body size categories, caimans occupied distinct isotopic regions in some habitats, indicating apparent niche segregation. Ontogenetic trophic shifts in the isotopes ($\delta^{13}\text{C}$ and $\delta^{15}\text{N}$) depended on sex, leading to resource partitioning that can potentially reduce intraspecific competition. Decision-makers and stakeholders should consider the trophic dynamics of sex and body size groups for the sustainable management and conservation of caiman populations, which implies in the maintenance of wetland habitats and landscape heterogeneity in the Formoso River floodplain.

Viljoen, D., Webb, E., Myburgh, J., Truter, C. and Myburgh, A. (2023). Remote body condition scoring of Nile crocodiles (*Crocodylus niloticus*) using Uncrewed Aerial Vehicle derived morphometrics. *Frontiers in Animal Science* 4 (doi: 10.3389/fanim.2023.1225396).

Abstract: Population surveys of crocodilians using uncrewed aerial vehicles (UAV) or drones may become accurate and cost-effective alternatives to more traditional approaches. However, there are currently no quantitative methods for deriving body condition scores of crocodilians through remote sensing. This study presents seven UAV-based morphometric measures collected from rectified aerial imagery of farmed Nile crocodiles. Two hundred and eighty-eight Nile crocodiles, from two commercial crocodile farms in South Africa were included in this study. One farm housed crocodiles which appeared to have wider abdominal girths than those on the second farm, allowing comparisons for a range of sizes and body condition states. An initial disturbance assessment was conducted, and an appropriate flight altitude selected for image acquisition of farmed Nile crocodiles. Altitudes between 40 m and 60 m above ground level suited the studies requirements and minimized disturbance. A UAV-based body condition index for Nile crocodiles was then developed, offering a non-invasive alternative to traditional condition scoring methods. The body condition index (BCI) was calculated for each crocodile by measuring the relationship between total length and belly width (with the equation: $\text{BCI} = \text{BW}/\text{TL} \times 10$) derived from photogrammetrically processed orthophotos in GIS. The BCI values were then normalized to form a body condition score (BCS) with the equation: $\text{BCS} = (\text{BCI}/1.27) \times 4 + 1$. The BCS ranked crocodile body conditions from 1-5, where a score of 1 identified a crocodile that was comparatively thin or emaciated, while a score of 5 identified a crocodile that was relatively fat or obese in contrast to the other crocodiles assessed. A BCS of 3 was the most frequent across all crocodiles in the study, with few animals scoring a 1 or 5. The farm housing crocodiles with narrower abdominal girths had no BCS 5 occurrences, and the farm housing crocodiles with wider abdominal girths had no BCS 1 occurrences. This UAV-based body

condition score could be applied to large wild or captive populations for a fast-paced health and welfare evaluation.

Kojima, L.V. (2023). Mercury Accumulation and Movement Ecology of the American Alligator (*Alligator mississippiensis*). MSc thesis, University of Georgia, Athens, Georgia USA.

Abstract: Mercury (Hg) is a naturally occurring element but is also considered a widespread contaminant due to global anthropogenic activity. Even in moderate amounts, mercury (Hg) is an established neurotoxin and is associated with a range of adverse outcomes both in humans and wildlife. I investigated the accumulation of Hg in American alligators (*Alligator mississippiensis*) on the United States Department of Energy's Savannah River Site (SRS) and assessed the risk of Hg exposure from the consumption of wild caught alligator meat from alligators that originate from the SRS. I also examined the relationships between Hg body burdens and drivers of alligator movement behavior and home range. My results demonstrate the use of alligators as a bioindicator species and tied together the relationships between aspects of broader ecological health with that of human health through alligator ecology and toxicology.

Rosenblatt, A.E., Greco, R., Beal, E., Colbert, J., Moore, Y., Baglin, V. and Nifong, J.C. (2023). Golf course living leads to a diet shift for American alligators. *Ecology and Evolution* 13: e10495.

Abstract: Human-driven land use change can fundamentally alter ecological communities, especially the diversity and abundance of large-bodied predators. Yet, despite the important roles large-bodied predators play in structuring communities through feeding, there have been only a few investigations of how the feeding patterns of large-bodied predators change in human-dominated landscapes. One group of large-bodied predators that has been largely overlooked in the context of land use change is the crocodylians. To help fill these gaps, we studied the feeding patterns of juvenile American alligators (*Alligator mississippiensis*) on neighboring barrier islands on the southeast coast of Georgia, USA. Jekyll Island has multiple golf courses and substantial amounts of human activity, while Sapelo Island does not have any golf courses and a much smaller amount of human activity. We found that juvenile alligator populations on both islands ate the same types of prey but in vastly different quantities. Sapelo Island alligators primarily consumed crustaceans while alligators that lived on Jekyll Island's golf courses ate mostly insects/arachnids. Furthermore, the Jekyll Island alligators exhibited a much more generalist feeding pattern (individuals mostly ate the same types of prey in the same quantities) than the more specialized Sapelo Island alligators (diets were more varied across individuals). The most likely explanation for our results is that alligators living on golf courses have different habitat use patterns and have access to different prey communities relative to alligators in more natural habitats. Thus, land use change can strongly alter the feeding patterns of large-bodied predators and, as a result, may affect their body condition, exposure to human-made chemicals, and role within ecological communities.

Doran-Myers, D., Parry, M., McHugh, S.M., McCollister, M., Scheick, B.K. and Shiver, S. (2023). American Black bears depredate American alligator nests in South Florida. *Southeastern Naturalist* 22(3): N58-N66.

Abstract: *Ursus americanus* (American Black Bear) and *Alligator mississippiensis* (American alligator) are sympatric in areas of Florida. During summer, alligators build nest mounds for eggs on freshwater shores, shallow marshes, and tree islands. Biologists have speculated that bears might prey upon alligator nests because of their opportunistic and generalist diet, though such predation in Florida has not been documented in peer-reviewed literature. Herein, we report 3 photographed events of American Black Bear predation on American alligator nests in Everglades National Park,

Big Cypress National Preserve, and Dinner Island Ranch Wildlife Management Area, FL. During each event, bears dug into alligator nests and consumed egg contents. The predation events varied in duration from 36 minutes to nearly 5 hours. During 1 event, a female bear consumed alligator eggs alongside 2 cubs of the year. Future research might explore the extent and effect of nest predation on American alligator populations and the benefits to American Black Bears.

Taborda, J.R.A., Belen von Baczko, M., and Desojo, J.B. (2023). Biomechanical analysis and new trophic hypothesis for *Riojasuchus tenuisiceps*, a bizarre-snouted Late Triassic pseudosuchian from Argentina. *Acta Palaeontologica Polonica* 68 (<https://doi.org/10.4202/app.01038.2022>).

Abstract: Ornithosuchids are a Late Triassic pseudosuchian archosaur group, consisting of four species (three from South America, and one from Scotland). All of them have triangular skulls with a protruding premaxilla, large nostrils, an extensive diastema in their narrow snout, a short jaw that does not reach the anterior end of the skull, and serrated posteriorly curved teeth. For this clade, carnivorous and scavenger habits have been previously proposed. Within the Ornithosuchidae, *Riojasuchus tenuisiceps* (from Argentina) has the most morphologically extreme characteristics. Based on CT scans of the preserved skulls we generated a 3D model, and over this, we estimated the volumes of the adductors and abductor muscles and the force exerted by each. From these data we built the finite element model and measured the bite force (1.8-2.3 kN). Lateral, tractive, and torsional forces were applied to the end of the snout to evaluate the structural response of the skull during feeding. The results show that *R. tenuisiceps* could resist tractive and torsional stresses better than lateral stress. Additionally, we analysed the peculiar morphological characteristics of the skull and their functional implications. We observed that the upper and lower dental rows were laterally separated from each other, preventing the generation of a cutting line during occlusion, and therefore, *R. tenuisiceps* would have fed on small-sized prey that it could swallow whole. The curved premaxilla and the short mandible would not allow it to bite with the tip of the snout (ruling out the scavenging hypothesis), but were instead more adequate to capturing prey suspended in a fluid. This set of results allows us to propose that *R. tenuisiceps* could have had a zoophagous diet and a wading habit, being able to feed on fish, amphibians, or any small animals that they could catch from the shoreline.

Pilliod, D.S. and Esque, T.C. (2023). Amphibians and reptiles. In *Rangeland Wildlife Ecology and Conservation*, ed. by L.B., McNew, D.K. Dahlgren and J.L. Beck. Springer: Cham.

Abstract: Amphibians and reptiles are a diverse group of ectothermic vertebrates that occupy a variety of habitats in rangelands of North America, from wetlands to the driest deserts. These two classes of vertebrates are often referred to as herpetofauna and are studied under the field of herpetology. In U.S. rangelands, there are approximately 66 species of frogs and toads, 58 salamanders, 98 lizards, 111 snakes, and 27 turtles and tortoises. Herpetofauna tend to be poorly studied compared with other vertebrates, which creates a challenge for biologists and landowners who are trying to manage rangeland activities for this diverse group of animals and their habitats. Degradation of habitats from human land use and alteration of natural processes, like wildfire, are primary threats to herpetofauna populations. Disease, non-native predators, collection for the pet trade, and persecution are also conservation concerns for some species. Properly managed livestock grazing is generally compatible with herpetofauna conservation, and private and public rangelands provide crucial habitat for many species. Climate change also poses a threat to herpetofauna, but we have an incomplete understanding of the potential effects on species. Dispersal and adaptation could provide some capacity for species to persist on rangelands as climates, disturbance regimes, and habitats change. However, inadequate information and considerable

uncertainty will make climate mitigation planning difficult for the foreseeable future. Planning for and mitigating effects of climate change, and interactions with other stressors, is an urgent area for research. Maintaining large, heterogeneous land areas as rangelands will certainly be an important part of the conservation strategy for herpetofauna in North America.

Khan, M.A.R. (2023). Bangladesh wildlife: A call to arrest its decline through remedial policies and management. Khulna University Stud. pp. 1-10.

Abstract: Bangladesh, located between latitudes 20°34' to 26°38' north and longitudes 88°01' to 92°41' east, is the most densely populated country in the world with 1252 people per one square kilometre; this is almost three times as dense as its neighbour, India (Ritchie, 2020), other than the island countries like Singapore, and others. So, Bangladesh is not likely to have a large array of wildlife, including both megafauna and macrofauna, and flora. However, because of its very zoo-geographic location in the Indo-Malayan realm of the Oriental Region (Cox, 2001), Bangladesh supports at least three major terrestrial habitats and similar number of aquatic environments. These have allowed the country to have astounding number of wildlife and plants, eg about 125 species of mammals, 718 species of birds, 2500 species of arthropods and 5700 species of vascular plants. However, it is not satisfied status because already lost few charismatic megafaunas such as, all three species of Asian rhinoceroses, water buffalo, swamp deer, two species of peafowls, swamp partridge, Bhadi Hans (white-winged duck, Khan, 1983a, 1983b, 2003), marsh crocodile, etc. Existing study posits that the country has already lost about 10% of its mammals, 3% birds and 4% of reptile species and an unknown number of amphibians, fishes, and invertebrates as well as plants. Another 14% of animal species are endangered (Khan, 2012). The same may very well be true for the plants. Currently the Forest Department, which has its own forestry policy from as early as 1979, has failed to develop such a policy for wildlife although it is trying to manage the wildlife of the country from the inception of Bangladesh in 1971. The department lacks in right workforce trained in wildlife with proper degree in relevant subjects. A few people that work there does not see progressions in their service career. The wildlife conservation policy followed round the world does not conform to the forestry policy of Bangladesh. So, Bangladesh must have a concrete wildlife and its sustainable management policy to conserve the wildlife wealth through creating a proper wildlife department to implement such a policy and save the wildlife from further killing or loss of wildlife through managerial failures or mismanagement.

Lensink, A.V. (2023). Bacterial and Fungal Penetration of the Nile Crocodile (*Crocodylus niloticus*) Egg in Relation to the Eggshell and Eggshell Membrane Anatomy and Microstructure. PhD thesis, University of Pretoria, Pretoria, South Africa.

Abstract: Commercial farming with the Nile crocodile (*Crocodylus niloticus*) for both leather and meat is an economically significant industry in South Africa. Due to the economic value of these products, effective captive breeding and hatchling rearing management programmes are of critical importance. An increase of knowledge and the investigation of specific crocodile industry related questions (identified interventions) in South Africa are of utmost importance to standardize and optimize Good Operating Practices for Nile crocodile husbandry, as well as to increase productivity on commercial farms. Low hatching rates have been identified as a management problem by most South African farms. Although many factors may contribute to the low hatching percentage, the role of bacterial and fungal contamination of the embryo inside the egg, has not been investigated before. For these microorganisms to clinically affect the healthy embryo, they must be able to gain access through the eggshell and the eggshell membrane. The role of the anatomy and microstructures of the eggshell in the prevention of intra-egg infections, and its changes during the incubation period is

also not well known. The Objectives of this project were to: (1) test, optimize and determine the most suitable preparation technique/set of techniques to comprehensively describe the microstructure of the Nile crocodile eggshell and eggshell membrane; (2) investigate and describe the normal anatomy of the Nile crocodile's eggshell and eggshell membranes and its changes during the incubation period; (3) identify the bacterial and fungal species prevalent on commercial crocodile farms and associated with the Nile crocodile egg after oviposition and during the incubation period; (4) investigate the penetration of bacterial and fungal species through the eggshell and membrane; and (5) determine if there is a correlation between the changing microstructure of the egg during incubation and the ability of microbes to penetrate the eggshell and eggshell membranes. Fifty unbanded *C. niloticus* eggs from 22 clutches, 12 nesting sites on three different farms were used for Objective 1. A variety of sample preparation and analysis methodologies and techniques was tested and optimized to study the micro- and ultrastructure of the inorganic eggshell and its associated organic eggshell membrane. For Objectives 2 and 3, *C. niloticus* eggs (n= 48) from 12 clutches, each from different nesting sites on three separate farms were collected. Four eggs from different incubation stages (one day -, one week -, 5 weeks - and 9 weeks after oviposition) were collected from each of the 12 clutches. During the first egg collection relevant environmental samples and samples from areas associated with the egg during incubation (nesting material, water, incubator boxes, vermiculite, and egg handlers' hands) were also collected for microorganism identification. For Objective 4, additional eggs from any clutch produced on the farms (n= 17) which showed external signs of microbial infection (discoloration, fine cracking, slimy to the touch, abnormal odour) or embryo death (egg cool to the touch) during the incubation period were identified and collected. Bacterial and fungal species were identified on all the collected samples and material using MALDI-TOF biomolecule analysis and ITS sequencing, respectively. Following testing and optimization of numerous techniques and sample preparation approaches, a combination of light and electron microscopy techniques, and micro/nano computed tomography was selected to investigate and comprehensively describe the anatomical and morphological information of the Nile crocodile eggshell and eggshell membranes. The *C. niloticus* egg is a translucent white ellipsoid egg and classified in the histological organization as a crocodyloid-type egg and comparative to similar species such as the American alligator. The shell is divided into three basic zones namely, the external, column/palisade and mammillary layers. The external layer is mainly composed of phosphorus and an amorphous form of calcite, the palisade layer of crystalline calcite arranged in large wedge-shaped shell units with traces of phosphorus, magnesium, sodium, and sulphur. The innermost mammillary layer is small irregular calcite crystals arranged in rosette-like structures in which the eggshell membrane fibres are embedded. The eggshell membrane is composed of several layers of organic fibre sheets arranged at right angles to one another, with a thin inner limiting membrane isolating the egg contents. Between the mammillary knobs and the membrane several airspaces exist which is connected to the pore channels running through the eggshell. Both the mammillary knobs and pore channels are found in higher densities at the equator of the egg reducing in number towards the egg poles; the shell is also at its thickest at the egg equator. During incubation, the mammillary knobs are the main source of calcium for the developing embryo, the calcium resorption can be seen as erosion and flattening of the mammillary knobs, thinning of the shell and a disruption in the shell-membrane connection. This movement of calcium also contribute to the colour change, known as banding, of the eggshell after fertilization and during incubation as higher amounts of calcium are found in the equatorial white area (banded) if compared to the unbanded area. Molecular analysis of 48 healthy, 17 dead-in-shell or infected eggs and environmental samples identified over 100 different bacterial species from 35 different genera and 22 fungal species from 10 genera. Fifteen bacterial species and 4 fungal species were found to be able to penetrate through the eggshell membrane and compromise the integrity of the egg contents and developing embryo. The diversity of species identified on the eggshell surface

and in the egg, contents changed notably during the incubation period, with bacterial and fungal species ultimately decreasing on the eggshell surface and increasing in the egg contents. A third of the bacterial species identified (eg *Aeromonas*, *Citrobacter*, *Escherichia*, *Proteus*, *Pseudomonas* and *Salmonella*) are known to be significant opportunistic pathogens and several have been implicated as causing reptile pathology and embryonic death in oviparous animals. At least 5 of the species of fungi found (ex. *Aspergillus*, *Fusarium* and *Lichtheimia*) are also well-known causative agents of crocodile disease and a few are problematic in poultry farming as they are known to be able to infect the egg contents. During the last collection period (\pm 9 weeks after oviposition) the diversity of bacterial and fungal species on the external shell surface increased sharply following a steady decline during the earlier stages of the incubation period. This corresponds to and might show a relationship with the constituent changes occurring in the external layer of the shell during the incubation period, ie the loss of phosphorus, which has been linked to reduced microbial defence and the entrance of bacteria in avian eggs. Additional correlation between the changing ultrastructure of the eggshell and its membrane, and the diversity of microbes found in association with the egg surface or content is insubstantial. Elapsed time, competitive challenges between microorganisms and the specificity of the artificial incubation environment favouring certain species are more likely to be the cause of the changes observed in the isolated bacterial and fungal species during the incubation period. The eggshell and microstructure are very well adapted through evolution for the successful reproduction of amniotes. Significant first-time observations and contradictions to previous findings relating to the eggshell and membrane structures of the Nile crocodile egg, including the pattern of variable shell thickness, the existence of airspaces, the distribution and presence of mammillae and pores, and the external layers' crystal structure and composition were made. This information advances the academic knowledge on the subject area of *C. niloticus* reproductive biology and can also be used in future studies to determine the synthesis requirements, in terms of adult nutrition to optimize and increase quality egg production. Knowledge of the fundamental parameters of the shell might also lead to optimized procedures in basic husbandry and the artificial incubation environment (Standard Operating Procedures). It seems as if the anatomy of the eggshell and eggshell membrane is not sufficient to stop the penetration of bacteria and fungi, although it does impede and slow down the movement of microbes adequately to allow embryo development to continue to a point where the embryo and other extraembryonic elements are more resistant to the detrimental effects of microbial penetration. If bacterial and fungal agents are not delayed and allowed to penetrate the eggshell and membrane during early-stages of embryonic development, there is a high risk of infection and embryo mortality. Penetration into the egg contents by microbes during the later developmental stages is still associated with possible pathologies due to indirect causes such as oxygen deprivation, toxic stress, or egg water depletion. High environmental microbial loads, egg handling and transport shortly after oviposition, and the introduction to shared artificial incubation spaces, as it is routinely practised in crocodile husbandry, introduce the collected eggs to numerous microorganisms. This exposure also occurs at a point during development where the egg is at its most susceptible to infection endangering the embryo, but also the commercial enterprise. The knowledge of the microbial diversity on farms, and in association with the time points or points where high loads of unnecessary microbes are introduced, will be able to be used to aid in specific interventions to reduce the microbial load, infection risks, embryo mortality and ultimately reduced hatchability. The knowledge of the specific organisms able to penetrate the physical barriers of the egg and the species most often associated with embryo pathogenicity and/or mortality can also be applied to identify and select treatment protocols of the collected eggs directed to target the specifically implicated microorganisms.

González-Desales, G., Charruau, P., Zarco-González, M.M. and Monroy-Vilchis, O. (2023). Factors influencing egg predation of

two sympatric crocodilians in Mexico. *Herpetological Conservation and Biology* 18(2): 404-414.

Abstract: The rates of eggs predation in crocodilians can be influenced by the abundance of predators, their activity time, the crocodilian size, and parental care. We evaluated the relationship between crocodilian eggs predation and characteristics of the predatory species (egg search intensity and activity hours), of the nesting females (nest defense), and of the nesting site (habitat characteristics and climatic variables). We evaluated nests with camera traps during the 2014 nesting seasons of Spectacled caimans (*Caiman crocodilus*) and American crocodiles (*Crocodylus acutus*) in the Biosphere Reserve La Encrucijada, Mexico. We identified a relationship between the defense of the nest and the search for eggs by predators. The number of photographic records of females on the nest increased with the number of photographic records of the egg predators. We observed overlap of activity hours between crocodilian females and egg predators. Females were recorded on the nest only when their predator species was present. In addition, some climatic variables (air temperature and rainfall) and nests characteristics (depth to the first egg and distance to the closest tree) were positively associated with the success of egg predation, depending on the predator species.

Toyota, K., Akashi, H., Ishikawa, M., Yamaguchi, K., Shigenobu, S., Sato, T., Lange, A., Tyler, C.R., Iguchi, T. and Miyagawa, S. (2023). Comparative analysis of gonadal transcriptomes between turtle and alligator identifies common molecular cues activated during the temperature-sensitive period for sex determination. *Gene* (doi: 10.1016/j.gene.2023.147763).

Abstract: The mode of sex determination in vertebrates can be categorized as genotypic or environmental. In the case of genotypic sex determination (GSD), the sexual fate of an organism is determined by the chromosome composition with some having dominant genes, named sex-determining genes, that drive the sex phenotypes. By contrast, many reptiles exhibit environmental sex determination (ESD), whereby environmental stimuli drive sex determination, and most notably temperature. To date, temperature-dependent sex determination (TSD) has been found in most turtles, some lizards, and all crocodylians, but commonalities in the controlling processes are not well established. Recent innovative sequencing technology has enabled investigations into gonadal transcriptomic profiles during temperature-sensitive periods (TSP) in various TSD species which can help elucidate the controlling mechanisms. In this study, we conducted a time-course analysis of the gonadal transcriptome during the male-producing temperature (26°C) of the Reeve's turtle (Chinese three-keeled pond turtle) *Mauremys reevesii*. We then compared the transcriptome profiles for this turtle species during the TSP with that for the American alligator *Alligator mississippiensis* to identify conserved reptilian TSD-related genes. Our transcriptome-based findings provide an opportunity to retrieve the candidate molecular cues that are activated during TSP and compare these target responses between TSD and GSD turtle species, and between TSD species.

Vargas-Ramirez, M., Forero-Medina, G., Moreno Torres, C. and Balaguera-Reina, S.A. (2023). Reintroduction of adult Orinoco crocodiles: a crucial step towards the species recovery promoting coexistence with the species. *Oryx* 57(5): 557-558.

Rodríguez, J.P. and Fisher, M. (2023). Assessment, planning and action for species conservation. *Oryx* 57(5): 545-546.

Hoffmann, R. and Roe, D. (2023). Sustainable Use and Livelihoods Specialist Group launches its Species Use Database. *Oryx* 57(5): 553-560.

Koch, A. and Schweiger, S. (2023). On the provenance of the two large gharials in the display collection of the Natural History Museum Vienna. *Bibliotheca Herpetologica* 17(8): 67-82.

Abstract: While exhibits in natural history museums have great value as display and teaching objects, they can also have a provenance that is fascinating and enlightening. One such example is the two, large gharial (*Gavialis gangeticus*) hides exhibited in the Natural History Museum Vienna. They were purchased in 1902 by Franz Steindachner, the then Intendant (Director), and impress with their enormous size of 453 cm and 543 cm, respectively. Although they have been in the museum's collections for 120 years, until recently very little was known about the origin of the two crocodiles and how they originally came to Vienna. During our provenance research, we were able to reconstruct considerable aspects of the path of the two unique specimens from South Asia via the famous animal trader Carl Hagenbeck and the Umlauff family business in Hamburg, Germany, to the Austrian capital. In addition, other large gharial specimens in European natural history museums from Umlauff are discussed and illustrated herein.

Payne, A.R.D., Mannion, P.D., Lloyd, G.T. and Davis, K.E. (2023). Decoupling speciation and extinction reveals both abiotic and biotic drivers shaped 250 million years of diversity in crocodile-line archosaurs. *Nature Ecology & Evolution* (<https://discovery.ucl.ac.uk/id/eprint/10176428>).

Abstract: Whereas living representatives of Pseudosuchia, crocodylians, number fewer than 30 species, more than 700 pseudosuchian species are known from their 250 million year fossil record, displaying far greater ecomorphological diversity than their extant counterparts. With a new time-calibrated tree of >500 species, we use a phylogenetic framework to reveal that pseudosuchian evolutionary history and diversification dynamics was directly shaped by the interplay of abiotic and biotic processes over hundreds of millions of years, supported by Information Theory analyses. Speciation, but not extinction, is correlated with higher temperatures in terrestrial and marine lineages, with high sea level associated with heightened extinction in non-marine taxa. Low lineage diversity and increased speciation in non-marine species is consistent with opportunities for niche-filling, whereas increased competition may have led to elevated extinction rates. In marine lineages, competition via increased lineage diversity appears to have driven both speciation and extinction. Decoupling speciation and extinction, in combination with ecological partitioning, reveals a more complex picture of pseudosuchian evolution than previously understood. As the number of species threatened with extinction by anthropogenic climate change continues to rise, the fossil record provides a unique window into the drivers that led to clade success and those that may ultimately lead to extinction.

Pees, M., Brockmann, M., Steiner, N. and Marschang, R.E. (2023). Salmonella in reptiles: a review of occurrence, interactions, shedding and risk factors for human infections. *Frontiers in Cellular and Developmental Biology* 11 (doi: 10.3389/fcell.2023.1251036).

Abstract: Salmonella are considered a part of the normal reptile gut microbiota, but have also been associated with disease in reptiles. Reptile-associated salmonellosis (RAS) can pose a serious health threat to humans, especially children, and an estimated 6% of human sporadic salmonellosis cases have been attributed to direct or indirect contact with reptiles, although the exact number is not known. Two literature searches were conducted for this review. The first evaluated reports of the prevalence of Salmonella in the intestinal tracts of healthy reptiles. Salmonella were most commonly detected in snakes (56.0% overall), followed by lizards (36.9%) and tortoises (34.2%), with lower detection rates reported for turtles (18.6%) and crocodylians (9%). Reptiles in captivity were significantly more likely to shed Salmonella than those sampled in the wild. The majority of Salmonella strains described in reptiles

belonged to subspecies I (70.3%), followed by subspecies IIIB (29.7%) and subspecies II (19.6%). The second literature search focused on reports of RAS, revealing that the highest number of cases was associated with contact with turtles (35.3%), followed by lizards (27.1%) and snakes (20.0%). Reptiles associated with RAS therefore did not directly reflect prevalence of Salmonella reported in healthy representatives of a given reptile group. Clinical symptoms associated with RAS predominantly involved the gastrointestinal tract, but also included fever, central nervous symptoms, problems with circulation, respiratory symptoms and others. Disease caused by Salmonella in reptiles appears to be dependent on additional factors, including stress, inadequate husbandry and hygiene, and other infectious agents. While it has been suggested that reptile serovars may cause more severe disease than human-derived strains, and some data is available on invasiveness of individual strains in cell culture, limited information is available on potential mechanisms influencing invasiveness and immune evasion in reptiles and in RAS. Strategies to mitigate the spread of Salmonella through reptiles and to reduce RAS focus mostly on education and hygiene, and have often been met with some success, but additional efforts are needed. Many aspects regarding Salmonella in reptiles remain poorly understood, including the mechanisms by which Salmonella persist in reptile hosts without causing disease.

Fawcett, M.J., Lautenschlager, S., Bestwick, J. and Butler, R.J. (2023). Functional morphology of the Triassic apex predator *Saurosuchus galilei* (Pseudosuchia: Loricata) and convergence with a post-Triassic theropod dinosaur. *Anatomical Record* (Hoboken) (doi: 10.1002/ar.25299).

Abstract: Pseudosuchian archosaurs, reptiles more closely related to crocodylians than to birds, exhibited high morphological diversity during the Triassic and are thus associated with hypotheses of high ecological diversity during this time. One example involves basal loricatans which are non-crocodylomorph pseudosuchians traditionally known as "rauisuchians." Their large size (5-8+ m long) and morphological similarities to post-Triassic theropod dinosaurs, including dorsoventrally deep skulls and serrated dentitions, suggest basal loricatans were apex predators. However, this hypothesis does not consider functional behaviors that can influence more refined roles of predators in their environment, for example, degree of carcass utilization. Here, we apply finite element analysis to a juvenile but three-dimensionally well-preserved cranium of the basal loricatan *Saurosuchus galilei* to investigate its functional morphology and to compare with stress distributions from the theropod *Allosaurus fragilis* to assess degrees of functional convergence between Triassic and post-Triassic carnivores. We find similar stress distributions and magnitudes between the two study taxa under the same functional simulations, indicating that *Saurosuchus* had a somewhat strong skull and thus exhibited some degree of functional convergence with theropods. However, *Saurosuchus* also had a weak bite for an animal of its size (1015-1885 N) that is broadly equivalent to the bite force of modern gharials (*Gavialis gangeticus*). We infer that *Saurosuchus* potentially avoided tooth-bone interactions and consumed the softer parts of carcasses, unlike theropods and other basal loricatans. This deduced feeding mode for *Saurosuchus* increases the known functional diversity of basal loricatans and highlights functional differences between Triassic and post-Triassic apex predators.

Bello, S.M. and Parfitt, S.A. (2023). Taphonomic approaches to distinguish chewing damage from knapping marks in Palaeolithic faunal assemblages. *Journal of Archaeological Science: Reports* 51 (<https://doi.org/10.1016/j.jasrep.2023.104183>).

Abstract: The imprint of human actions on mammal remains from archaeological sites is often fragmented and attenuated due to post-mortem processes, which add to the challenge of distinguishing human from natural modifications in faunal assemblages. Identifying minimally-worked bone tools poses a particular challenge when they are mixed with bones that have been modified by other agents.

Bones, antlers and teeth used as hammers or pressure-flakers in flint-knapping can be particularly difficult to identify because knapping damage resembles carnivore chewing marks. This paper presents a methodological approach to establish diagnostic criteria for identifying whether bones from archaeological sites were modified by chewing or knapping, using observations at macroscopic and microscopic levels. We applied these criteria to case studies from the Upper Palaeolithic (Magdalenian) site of Gough's Cave (UK). Analysis of Magdalenian stone tools shows that blades were detached with a soft hammer, yet organic (soft) knapping tools appear to be scarce in Magdalenian contexts. We propose that the difficulty in identifying knapping damage on bones that have undergone only a short period of use, combined with the macroscopic similarity of these marks with natural modifications (eg carnivore chewing), are significant factors contributing to the rarity of minimally-modified knapping tools in archaeological contexts.

Baxter, M. (2023). Dynamics of the Caiman Trade from the Perspective of Guyana. MSc thesis, University of Kent, UK.

Abstract: The international wildlife trade is a core issue in the preservation of biodiversity, with the wildlife trade leading to overexploitation and habitat loss it is imperative to study long-term trends. The wildlife trade has changed domestically and internationally. Historically animals have been primarily traded for parts, products and derivatives such as ivory, bones, scales and skins. Yet, urbanisation and globalisation have made access to products easier and altered the market, as seen through an increase in the live trade of animals and reptiles. Caimans are traditionally traded for their skins but a recent rise in demand for exotic meat and pet caimans makes them a prime example of new trends in the wildlife trade. This study aims to explore the patterns in the caiman trade over time. We incorporate interviews with members of the caiman trade in Guyana and an analysis of the CITES trade database for caimans from Guyana and the rest of South/Central America between 2011 and 2022. Our research reveals a slow decline in both quantities of individual items and the volume of countries that import caimans. Our interviews also showed that the USA and Asia are significant contributors to the current caiman trade. All exporters reported selling only live caimans in recent years, corroborated by the CITES database, with over 95% of products being live caimans. This study estimates that within Guyana there has been an increase in demand for live caimans and as such studying this is needed to help management practices.

Viveros-Peredo, S.A., Ahuja-Aguirre, C., Lopez-deBuen, L. and Vega-Murillo, V.E. (2023). Length and weight of farmed young Morelet's crocodiles (*Crocodylus moreletii*) as predictors of their future size. Aquaculture (<https://doi.org/10.1016/j.aquaculture.2023.740088>).

Abstract: The aim of the study was to determine the earliest time at which the future size (length and weight) of farmed Morelet's crocodiles (*Crocodylus moreletii*) can be accurately predicted, to establish selection criteria in these individuals. A total of 8040 crocodiles (7394 males and 646 females) hatched from artificially incubated eggs were included. In each crocodile the total length and weight were measured on days 1, 132, 248, 364, 500, 616, 750, and 878 of age. On day 878 crocodiles were classified into five size groups: runt (RT), small (SL), medium (MM), large (LG), and extra-large (EL). The association between evaluations for length and weight, the correlation between length and weight in each measurement, and the differences in length and weight between assessments and sex were determined. Analysis from day 132 through day 878 included both sexes together. Neither length nor weight on day one correlated (>0.40) with any subsequent evaluation. There was no difference among groups ($P>0.05$) between length on day one and size on day 878. Difference was found between length on day 132 and size on day 878 in RT ($P<0.05$), and between length on days 248, 364, 616, and 750 and size on day 878 in all the groups ($P<0.05$). Difference

was found between weight on day one and size on day 878 only in SL ($P<0.05$), and between weight on days 132, 248, 364, 616, and 750 and size on day 878 in all the groups ($P<0.05$). The size farmed Morelet's crocodiles will have at 878 days can be predicted with weight at 132 and length at 248 days. Use of the ranges of the size groups as selection criteria for growth will allow selecting the future smallest and largest individuals early in the production cycle and to enhance sustainable management of this species.

Yun, C-G. (2024). Spinosaur as phytosaur mimics: A case of convergent evolution between two extinct archosauriform clades. Acta Palaeontologica Romaniae 20(1): 17-29.

Abstract: Spinosaurids are a highly morphologically specialized clade of large tetanuran theropod dinosaurs, characterized by their proportionally long, narrow snouts and conical teeth with fluted surfaces. The unusual morphology of spinosaurids has been usually compared with modern crocodilians, but distinct differences between them have been reported as well. Here, numerous craniodental characters that are shared by spinosaurids and large, robust phytosaurs often termed as "brachyrostral" forms are reviewed. Phytosaurs are a clade of carnivorous archosauriforms that resemble crocodilians in overall morphology, and as such a similar lifestyle has been inferred for them as well. Although based on preliminary observations, the shared craniodental characters of spinosaurids and "brachyrostral" phytosaurs, including those not shared with crocodilians, raise the possibility that at least some aspects of the lifestyle of these extinct archosauriform clades were more similar to each other rather than to that of crocodilians.

Botha, J., Weiss, B.M., Dollman, K., Barrett, P.M., Benson, R.B.J. and Choiniere, J.N. (2023). Origins of slow growth on the crocodilian stem lineage. Current Biology ([doi: 10.1016/j.cub.2023.08.057](https://doi.org/10.1016/j.cub.2023.08.057)).

Abstract: Crocodilians grow slowly and have low metabolic rates similar to other living reptiles, but palaeohistology indicates that they evolved from an ancestor with higher growth rates. It remains unclear when slow growth appeared in the clade due to the sparse data on key divergences among early Mesozoic members of their stem lineage. We present new osteohistological data from a broad sample of early crocodylomorphs, evaluated in a phylogenetic context alongside other pseudosuchians. We find that the transition to slow-growing bone types during mid-late ontogeny occurred around the origin of Crocodylomorpha during the Late Triassic. Earlier-diverging pseudosuchians had high maximum growth rates, as indicated by the presence of woven bone during middle and (sometimes) late ontogeny. Large-bodied pseudosuchians in particular exhibit some of the fastest-growing bone types, giving evidence for prolonged, rapid growth. By contrast, early-branching crocodylomorphs, including a new large-bodied taxon, had slow maximum rates of bone deposition, as evidenced by the presence of predominantly parallel-fibered or lamellar bone tissue during middle-late ontogeny. Late Triassic crocodylomorphs show skeletal anatomy consistent with "active" terrestrial habits and their slow growth rates reject hypotheses linking this transition with sedentary, semiaquatic lifestyles or sprawling posture. Faster-growing pseudosuchian lineages go extinct in the Triassic, whereas slow-growing crocodylomorphs do not. This contrasts with the Jurassic radiation of fast-growing dinosaurs on the bird-stem lineage, suggesting that the End-Triassic mass extinction initiated a divergent distribution of growth strategies that persist in present-day archosaurs.

Marques Bitencourt, M. and Maschio, G.F. (2023). Incidence and characteristics of crocodilian incidents on humans in Brazil in the period 2000-2022. The Herpetological Journal 33(3): 76-82.

Abstract: Brazil has the largest diversity of crocodilians in the world, with six species present in the country. Considered as opportunistic

generalist predators, these animals occupy the top of the food chain in river ecosystems. Anthropogenic actions result in an impact both on habitats and on the behaviour of the crocodilians, in addition to facilitating the encounter between humans and crocodilian species. In this study, we evaluated the characteristics of alligator incidents on humans in Brazil during the years 2000-2022. We used online platforms for scientific articles and news, collecting information about the victims, the species involved, and the locality of occurrence. We found 86 records of incidents, of which 18 resulted in the victim's death. The Amazon biome encompasses the highest number of incidents, and the black caiman *Melanosuchus niger* was the species involved most. Most incidents (n= 35) occurred with people who were fishing or on boats. Considering the size of the country's population, alligator incidents on humans in Brazil can be considered rare, but they should not be overlooked. The advancement of activities that degrade the environment, causing imbalances, can cause an increase in the likelihood of encounters and, consequently, incidents, which usually generates critical medical problems and negative consequences for the populations of these animals.

Thomas, R.A. (2023). Louisiana's bold plan to use scientific knowledge of the natural history of the American alligator, *Alligator mississippiensis* (Daudin 1801), to save the species from extinction. Occasional Paper Loyola Center for Environmental Communication (5 vers. 2.1): 1-14.

Fernández, M.S., Piazza, M. and Simoncini, M.S. (2023). Do ontogenetic changes during incubation interfere with the interpretation of incubation mode in dinosaur eggs? Historical Biology (<https://doi.org/10.1080/08912963.2023.2257956>).

Abstract: Dinosaurs are oviparous reptiles that belong to Archosauria and whose closest modern relatives are crocodiles and birds. This is why, to shed light on the study of dinosaur reproduction, we conducted a test with the species *Caiman latirostris* (Crocodylia), a living archosaur. This paper focuses on the study of the embryos' effect on the eggshells of *Caiman latirostris* during incubation. A total of 30 eggs from four nests including both embryonated and non-embryonated eggs were artificially incubated under the same conditions (incubation medium and temperature) to observe changes in eggshell structure throughout embryonic development. We found significant differences between eggs, in the embryonated eggshells we observed that the continuous calcium layer, became thinner, while at the same time we recorded an increase in the porosity of the eggshells both in the polar and equatorial regions. These changes could explain the variability recorded in fossil deposits with broods, where shells of the same oospecies were found at different levels and with differences in porosity and thickness. The results of this study will contribute to the methodology behind the inference of nesting environment and nesting strategies (buried, semi-buried or exposed) for fossil eggs, which typically utilises calculations of water vapour conductance.

Bouchemla, I., Benyoucef, M., Klein, H. and Adaci, M. (2023). First tetrapod swim traces and associated ichnofauna from the Mesozoic of Algeria, North Africa. Ichnos (<https://doi.org/10.1080/10420940.2023.2258261>).

Abstract: We report tetrapod traces and associated ichnofauna from two stratigraphic, dominantly terrestrial levels of the Tiout Formation (Valanginian-latest Albian to lower Cenomanian) in Laghouat and Brezina areas, Central Saharan Atlas (Djebel Amour), northwestern Algeria and discuss their paleoecological implications. The assemblages display abundant footprints that show similarities with crocodylian swim traces assigned to *Hatcherichnus* known from Jurassic-Cretaceous deposits of North America and Morocco. However, there is also some similarity in shape with traces attributed to swimming pterosaurs by different authors. Because of the isolated materials from Algeria and the lack of distinct trackways, we leave

the decision on the tracemaker open. The majority of the traces are tridactyl to tetradactyl imprints consisting of parallel furrows left by the claws of swimming or buoyant individuals. Tetrapod swim traces are identified, described, and figured herein for the first time from the Mesozoic of Algeria. These vertebrate fossil traces are associated with a low-diversity invertebrate marine ichnofauna, including cf. *Bergaueria* isp., *Phycodes* isp., *Sinusichnus* cf. *seilacheri*, and *Thalassinoides suevicus*. Together with body fossil data, including abundant fishes and non-avian dinosaurs, they indicate a diverse animal community populating a fluvial system environment with marine influence. Paleoecological and paleoenvironmental features of the Tiout Formation add new information to the ichnoassemblages previously reported from the 'mid'-Cretaceous of North Africa.

Ahlat, O., Ozoner, O., Filikci, K. and Atalay Vural, S. (2023). Mycobacteriosis in a Nile crocodile (*Crocodylus niloticus*) from Turkey. Ankara Üniversitesi Veteriner Fakültesi Dergisi (<https://doi.org/10.33988/auvfd.1139830>)

Abstract: In this case, mycobacteriosis in a Nile crocodile's tissues, which were sent from a private zoo, was described pathomorphologically and immunohistochemically. Macroscopically; multifocal, greyish-white areas were observed in the sent lung, liver and spleen. Histologically, a large number of well-demarcated necrotic areas were seen. These areas included nuclei debris locally. Moderate inflammatory cells and a couple of multinucleated giant cells surrounded the necrotic cores. Numerous acid-fast bacilli were detected by Ziehl-Neelsen staining method. Immunolabelling for both *Mycobacterium bovis* and anti-BCG antibodies was positive in each tissue.

Adler, J.(2023). Tarnished gold: The Endangered Species Act at 50. Faculty Publications 2194 (https://scholarlycommons.law.case.edu/faculty_publications/2194).

Abstract: The ESA is arguably the most powerful and stringent federal environmental law on the books. Yet for all of the Act's force and ambition, it is unclear how much the law has done much to achieve its central purpose: the conservation of endangered species. The law has been slow to recover listed species and has fostered conflict over land use and scientific determinations that frustrate cooperative conservation efforts. The Article aims to take stock of the ESA's success and failures during its first fifty years, particularly with regard the conservation of species habitat on private land. While the Act authorizes powerful regulatory tools for species conservation, there are serious questions as to whether such tools are the most effective means of conserving species and the habitats on which they rely. Given that most species rely upon private land for their survival, the Act's ability to foster private land conservation is will affect the law's overall success.

Anderson, J.T. (2023). Wetlands and Wildlife for the Future: The Clemson University James C. Kennedy Waterfowl and Wetlands Conservation Center. Jalaplavit 13(2): 15-21.

Yates, A.M., Ristevski, J. and Salisbury, S.W. (2023). The last *Baru* (Crocodylia, Mekosuchinae): a new species of 'cleaver-headed crocodile' from central Australia and the turnover of crocodylians during the Late Miocene in Australia. Papers in Palaeontology 9(5): e1523 (<https://doi.org/10.1002/spp2.1523>).

Abstract: *Baru* is a genus that includes several large mekosuchine crocodylians from the Oligo-Miocene of Australia. Here we describe *Baru iylwenpeny* sp. nov. from a large sample of cranial bones from the Upper Miocene Alcoota Local Fauna of the Northern Territory. *Baru iylwenpeny* can be diagnosed by several autapomorphies that include, but are not limited to: extreme reduction of the pneumatic foramina associated with the diverticula that invade the bones of

the suspensorium; and enlargement of the postcaniniform maxillary teeth resulting in crowding of the postcaniniform alveoli and a reduction in the number of maxillary alveoli to 12. The new species is the geologically youngest known member of the genus. While species of *Baru* are a ubiquitous component of Oligo-Miocene crocodylian assemblages from northern Australia, they are absent from all known Plio-Pleistocene sites, suggesting the extinction of the genus by the latest Miocene. We suggest that the marked taxonomic turnover of crocodylian assemblages between the Upper Miocene Alcoota Local Fauna and the Lower Pliocene is the result of a short period of severe aridity during the latest Miocene, causing widespread crocodylian extinctions across Australia, followed by the establishment of taxonomically novel crocodylian faunas in the Pliocene. This event mirrors similar contemporary losses of crocodylian diversity in Africa and South America, although these cases are partly driven by local tectonic events. It is likely that late Cenozoic global cooling also played a role in these extinctions.

Alibardi, L. (2023). Scales of non-avian reptiles and their derivatives contain corneous beta proteins coded from genes localized in the Epidermal Differentiation Complex. *Tissue and Cell* (<https://doi.org/10.1016/j.tice.2023.102228>).

Abstract: The evolution of modern reptiles from basic reptilian ancestors gave rise to scaled vertebrates. Scales are of different types, and their corneous layer can shed frequently during the year in lepidosaurs (lizards, snakes), 1-2 times per year in the tuatara and in some freshwater turtle, irregularly in different parts of the body in crocodilians, or simply wore superficially in marine and terrestrial turtles. Lepidosaurs possess tuberculate, non-overlapped or variably overlapped scales with inter-scale (hinge) regions. The latter are hidden underneath the outer scale surface or may be more exposed in specific body areas. Hinge regions allow stretching during growth and movement so that the skin remains mechanically functional. Crocodilian and turtles feature flat and shield scales (scutes) with narrow inter-scale regions for stretching and growth. The epidermis of non-avian reptilian hinge regions is much thinner than the exposed outer surface of scales and is less cornified. Despite the thickness of the epidermis, scales are mainly composed of variably amount of Corneous Beta Proteins (CBPs) that are coded in a gene cluster known as EDC (Epidermal Differentiation Complex). These are small proteins, 100-200 amino acid long of 8-25 kDa, rich in glycine and cysteine but also in serine, proline and valine that participate to the formation of beta-sheets in the internal part of the protein, the beta-region. This region determines the further polymerization of CBPs in filamentous proteins that, together a network of Intermediate Filament Keratins (IFKs) and other minor epidermal proteins from the EDC make the variable pliable or inflexible corneous material of reptilian scales, claws and of turtle beak. The acquisition of scales and skin derivatives with different mechanical and material properties, mainly due to the evolution of reptile CBPs, is essential for the life and different adaptations of these vertebrates.

Siddiqui, R., Akbar, N., Maciver, S.K., Alharbi, A.M., Alfahemi, H. and Khan, N.A. (2023). Gut microbiome of *Crocodylus porosus* and cellular stress: inhibition of nitric oxide, interleukin 1-beta, tumor necrosis factor-alpha, and prostaglandin E2 in cerebrovascular endothelial cells. *Archives in Microbiology* 205(10) (doi: [10.1007/s00203-023-03680-z](https://doi.org/10.1007/s00203-023-03680-z)).

Abstract: Crocodiles are renowned for their resilience and capacity to withstand environmental stressors, likely influenced by their unique gut microbiome. In this study, we determined whether selected gut bacteria of *Crocodylus porosus* exhibit anti-inflammatory effects in response to stress, by measuring nitric oxide release, interleukin 1-beta, tumor necrosis factor-alpha, and prostaglandin E2 in cerebrovascular endothelial cells. Using the Griess assay, the findings revealed that among several *C. porosus* gut bacterial isolates, the conditioned media containing the metabolites of two

bacterial strains (CP27 and CP36) inhibited nitric oxide production significantly, in response to the positive control, i.e., taxol-treatment. Notably, CP27 and CP36 were more potent at reducing nitric oxide production than senolytic compounds (fisetin, quercetin). Using enzyme linked immunosorbent assays, the production of pro-inflammatory cytokines (IL-1 β , TNF- α , PGE2), was markedly reduced by treatment with CP27 and CP36, in response to stress. Both CP27 and CP36 contain a plethora of metabolites to exact their effects [(3,4-dihydroxyphenylglycol, 5-methoxytryptophan, nifedipine, 4-chlorotestosterone-17-acetate, 3-phenoxypropionic acid, lactic acid, f-Honauin A, 1,1-Cyclo(leucylpropyl), 3-hydroxy-decanoic acid etc.], indicative of their potential in providing protection against cellular stress. Further high-throughput bioassay-guided testing of gut microbial metabolites from crocodiles, individually as well as in combination, together with the underlying molecular mechanisms, *in vitro* and *in vivo* will elucidate their value in the rational development of innovative therapies against cellular stress/gut dysbiosis.

Sosiangdi, S., Taemaitree, L., Tankrathok, A., Daduang, S., Boonlue, S., Klaynongsruang, S. and Jangpromma, N. (2023). Rational design and characterization of cell-selective antimicrobial peptides based on a bioactive peptide from *Crocodylus siamensis* hemoglobin. *Scientific Reports* 13(1) (doi: [10.1038/s41598-023-43274-9](https://doi.org/10.1038/s41598-023-43274-9)).

Abstract: Antimicrobial resistance is a growing health concern. Antimicrobial peptides are a potential solution because they bypass conventional drug resistance mechanisms. Previously, we isolated a peptide from *Crocodylus siamensis* hemoglobin hydrolysate, which has antimicrobial activity and identified the main peptide from this mixture (QL17). The objective of this work was to evaluate and rationally modify QL17 in order to: (1) control its mechanism of action through bacterial membrane disruption; (2) improve its antimicrobial activity; and (3) ensure it has low cytotoxicity against normal eukaryotic cells. QL17 was rationally designed using physicochemical and template-based methods. These new peptide variants were assessed for: (1) their *in vitro* inhibition of microbial growth, (2) their cytotoxicity against normal cells, (3) their selectivity for microbes, and (4) the mode of action against bacteria using scanning electron microscopy (SEM), transmission electron microscopy (TEM) and confocal microscopy. The results indicate that all designed peptides have more potent antimicrobial efficacy than QL17 and IL15 peptides. However, only the most rationally modified peptides showed strong antimicrobial activity and minimal toxicity against normal cells. In particular, IL15.3 (hydrophobicity of 47% and net charge of +6) was a potent antimicrobial agent (MIC= 4-12 μ g/mL; MBC= 6-25 μ g/mL) and displayed excellent selectivity for microbes (cf. human cells) via FACS assays. Microscopy confirmed that IL15.3 acts against bacteria by disrupting the cell membrane integrity and penetrating into the membrane. This causes the release of intracellular content into the outer environment leading to the death of bacteria. Moreover, IL15.3 can also interact with DNA suggesting it could have dual mode of action. Overall, a novel variant of QL17 is described that increases antimicrobial activity by over 1000-fold (~5 μ g/mL MIC) and has minimal cytotoxicity. It may have applications in clinical use to treat and safeguard against bacteria.

Newsom, A., Sebesvari, Z. and Dorresteijn, I. (2023). Climate change influences the risk of physically harmful human-wildlife interactions. *Biological Conservation* 286 (<https://doi.org/10.1016/j.biocon.2023.110255>).

Abstract: Interactions with wildlife can pose substantial physical risk to humans, as well as damage efforts to protect the species involved. News reports of increasing dangerous interactions with animals indicate climate change may be acting as a risk magnifier for these confrontations, yet its impacts on human-wildlife interactions remain uncertain in the scientific discourse. We analysed 331 media reports on climate change driven human wildlife conflicts involving

physically dangerous species and verified the effects found in the media with evidence from scientific literature. Our analysis showed that climate change can increase wildlife-induced physical harm to people. This result was consistent for venomous species, terrestrial- and aquatic carnivorous species and large-bodied terrestrial animals in 44 countries across the globe. We identified four climate driven trends that impact the risk of human casualties: i) increased resource competition between humans and wildlife due to drought; ii) range expansion of dangerous animals due to higher average temperatures; iii) temporary displacement of wildlife due to extreme weather events; iv) and changes in temporal behaviour patterns of wildlife due to higher average temperatures. The identification of overarching trends across different regions and species show the need to bridge the gap between wildlife research and the study of climate-related risks. The existence of, or potential for, wildlife-induced physical harm to people should be taken into account as a component of climate change driven risk. At the same time, we stress the importance of including current and future impacts of climate change into long-term wildlife management- and conservation schemes.

Stewart, K., Carmona, C.P., Clements, C., Venditti, C., Tobias, J.A. and González-Suárez, M. (2023). Functional diversity metrics can perform well with highly incomplete data sets. *Methods in Ecology and Evolution* (<https://doi.org/10.1111/2041-210X.14202>).

Abstract: Characterising changes in functional diversity at large spatial scales provides insight into the impact of human activity on ecosystem structure and function. However, the approach is often based on trait data sets that are incomplete and unrepresentative, with uncertain impacts on functional diversity estimates. To address

this knowledge gap, we simulated random and biased removal of data from three empirical trait data sets: an avian data set (9579 species), a plant data set (2185 species) and a crocodilian data set (25 species). For these data sets, we assessed whether functional diversity metrics were robust to data incompleteness with and without using imputation to fill data gaps. We compared two metrics each calculated with two methods: functional richness (calculated with convex hulls and trait probabilities densities) and functional divergence (calculated with distance-based Rao and trait probability densities). Without imputation, estimates of functional diversity (richness and divergence) for birds and plants were robust when 20%-70% of species had missing data for four out of 11 and two out of six continuous traits, respectively, depending on the severity of bias and method used. However, when missing traits were imputed, functional diversity metrics consistently remained representative of the true value when 70% of bird species were missing data for four out of 11 traits and when 50% of plant species were missing data for two out of six traits. Trait probability densities and distance-based Rao were particularly robust to missingness and bias when combined with imputation. Convex hull-based estimations of functional richness were less reliable. When applied to a smaller data set (crocodilians, 25 species), all functional diversity metrics were much more sensitive to missing data. Expanding global morphometric data sets to represent more taxa and traits, and to quantify intraspecific variation, remains a priority. In the meantime, our results show that widely used methods can successfully quantify large-scale functional diversity even when data are missing for half of species, provided that missing traits are estimated using imputation. We recommend the use of trait probability densities or distance-based Rao when working with large incomplete data sets and filling data gaps with imputation.

Steering Committee of the Crocodile Specialist Group

Chairs: Alejandro Larriera and Charlie Manolis, P.O. Box 530, Karama, NT 0813, Australia

For further information on the CSG and its programs on crocodile conservation, biology, management, farming, ranching, or trade, contact the Executive Office (csg@wmi.com.au) or Regional Chairs

Deputy Chair: Christine Lippai (lippainomad@gmail.com); Dr. Perran Ross (pross@ufl.edu)

Executive Officer: Dr. Sally Isberg, P.O. Box 530, Karama, NT 0813, Australia (csg@wmi.com.au)

Regional Chairs, East and Southern Africa: Dr. Xander Combrink (xandercombrink@gmail.com). **Regional Vice Chairs:** Christine Lippai (lippainomad@gmail.com); Dr. Alison Leslie (aleslie@sun.ac.za); Howard Kelly (crocfarm@venturenet.co.za)

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