

# CROCODILE SPECIALIST GROUP NEWSLETTER

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# CROCODILE

# SPECIALIST

# GROUP

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VOLUME 41 Number 2  
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IUCN - Species Survival Commission

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**COVER PHOTOGRAPH:** African Slender-snouted crocodiles (*Mecistops cataphractus*) in Ghana. Photographs: Threatened Species Conservation Alliance (top left, bottom right), Vladimir Wrangel (top right), Roger de la Harpe (bottom left). See also pages 14-15.

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**EDITORIAL POLICY:** All news on crocodylian conservation, research, management, captive propagation, trade, laws and regulations is welcome. Photographs and other graphic materials are particularly welcome. Information is usually published, as submitted, over the author's name and mailing address. The editors also extract material from correspondence or other sources and these items are attributed to the source. If inaccuracies do appear, please call them to the attention of the editors so that corrections can be published in later issues. The opinions expressed herein are those of the individuals identified and are not the opinions of CSG, the SSC or the IUCN unless so indicated.

## 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 crocodylians, and on the activities of the CSG. It is available as a free electronic, downloadable copy from "<http://www.iucncsg.org/pages/Publications.html>".

All CSG communications should be addressed to:  
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## Contributors (\$250 - \$1000)

James Hennessy, The National Reptile Zoo, Ireland.

Frank Robb, Florida, USA.

Allan Woodward, Florida, USA.

## Editorial

In February 2022, we reported that CSG Chair Grahame Webb was stepping down temporarily from most duties in order to assist his recovery from a minor accident. We are happy to report that his recovery has been good, and is again involving himself in CSG issues.

The 26th CSG Working Meeting was held on 3-8 July 2022, in Chetumal, Mexico. For the first time in its history, the CSG Steering Committee was conducted through Zoom. We had a very productive Steering Committee meeting with 15 members connected virtually and other 15 in the room, plus more than 20 observers. The COVID-19 pandemic has forced us to adapt to alternate ways of holding meetings, and although our preference is to have them face-to-face, the technology will no doubt be used in the future to include “virtual” participation. Likewise, at the Working Meeting, people were able to participate virtually in various sessions.

Detailed reports on the Steering Committee meeting and the Working Meeting (including workshops, side meetings, auction) will be included in the July-September issue of the Newsletter. However, we take this opportunity to congratulate the meeting hosts, and the State and Federal Governments, for a very successful meeting.

At the next Conference of the Parties to CITES (CoP19), to be held in Panamá in November 2022, three amendment proposals on crocodylians will be considered: Thailand, *Crocodylus siamensis*; Philippines, *Crocodylus porosus*; and, Brazil, *Caiman latirostris*. The CSG has subsequently been asked to review the proposals on behalf of IUCN. As always, CSG members will participate at CoP19, on delegations, as NGOs, as part of the IUCN delegation, etc.

The IUCN has released a publication on the application of indigenous and local knowledge (ILK) in Red List assessments (IUCN 2022; see page 25 for citation and Summary). The recognition of the importance of ILK is significant, and guidance on how to apply ILK in assessments will no doubt assist the CSG’s Red List team.

We congratulate CSG regional Vice Chair Emmanuel Amoah, who was awarded a prestigious Whitley Award in April 2022. Full details are on pages 14-15.

The 27th Working Meeting will be held in Darwin, Australia, in mid-2024. Details will be posted on the CSG website and in the Newsletter as they come to hand.

Charlie Manolis and Alejandro Larriera, *Interim Joint CSG Chairs*.

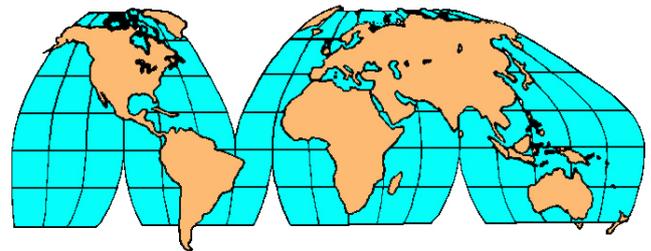
## CSG Student Research Assistance Scheme

The Student Research Assistance Scheme (SRAS) and Fritz Huchzermeyer Veterinary Science Student Research Assistance Scheme (FHVS-SRAS) provided funding to three students in the April-June 2022 quarter, and 5 applications are currently under review.

1. Helena Wood-Barron (USA): Croc calls: How American and Morelet’s crocodile vocalizations differ in structure.
2. Yu Umeki (USA): Hepatic metabolic physiology of pollutant biotransformation in American alligators (*Alligator mississippiensis*).
3. Everett Madsen (USA): Influence of nest substrate on American Crocodile (*Crocodylus acutus*) hatchling viability in Belize.

Tom Dacey, CSG Executive Officer ([csq@wmi.com.au](mailto:csq@wmi.com.au)).

## Regional Reports



### South Asia and Iran

**EARLY CAREER CROCODILE NETWORK LAUNCHED.** This year saw the launch of the Early Career Crocodile Network (ECCN) for Asia, an interactive online platform designed to bring together those across Asia who are early in their careers working on crocodylians. Perhaps one of the positives of the last two years has been that we are now all so used to virtual meetings that a network such as this has become possible!

The goal of the ECCN network is to bring together those of us who are early in a career working with crocodylians in a low-pressure and informal environment. We want to help connect people working in similar regions and create opportunities for discussion and experience sharing. As well as this, we intend to host regular expert talks and Q&A sessions to learn from experienced ‘croc people’ for advice and inspiration.

The ECCN network was founded by co-chairs Brinky Desai and Phoebe Griffith, who are supported by Lonnie McCaskill as Network Mentor and Dax Pandhi for technical support for maintaining the website and social media.

The first ECCN event was held in January 2022 where all the members met the chairs and each other sharing their introductions and the details of their ongoing projects. The

Chairs were working on forming the network since August 2021. There have been regular meetings and discussion sessions to share knowledge and experience, as well as build collaborations and friendships. There are currently 40 members from 5 Asian countries, and we look forward to welcoming members from more countries moving forward.

For our inaugural expert speaker event in February 2022, we were delighted to be joined online by Romulus Whitaker (Fig. 1), who talked us through his remarkable journey of 50 years working with crocodylian conservation across various countries. Ansem de Silva kindly wrote a note on the inception of the network, supporting its activities and creation. Soham Mukherjee gave a talk in March 2022 on crocodylian behaviour as a part of his captive work with crocodylian enrichment and projects involving conservation and conflict mitigation. In April 2022, Gowri Mallapur shared insights into her professional journey as a veterinarian and herpetologist working with crocodylians and other reptiles across India. Most recently, Nikhil Whitaker gave a talk sharing his academic journey as well as his journey as a researcher and head curator at the Madras Crocodile Bank Trust. We look forward to welcoming Rob Stuebing as our forthcoming speaker in August.

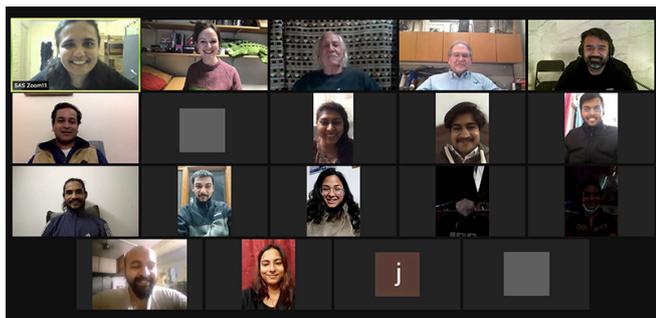


Figure 1. Participants at first ECCN expert speaker event, featuring Rom Whitaker.

Our plans for ECCN members in the near future are:

1. To have sessions where members break into smaller groups to discuss their projects and share ideas. The aim is to develop positive collaborations and have a chance to get to know one another.
2. To provide a forum for members to present their work to others, to get constructive input, and also as a way of practicing presentation and discussion with peers in advance of presenting to other audiences.
3. To have online workshops on project planning, grant writing, to help members develop projects and gain funding. We also plan to eventually raise funds to support members' work on early career projects, helping them to develop and run their projects.

The ECCN network is open to anyone in the early career stage in Asia, currently working on crocodylians for research, conservation, or education (including veterinary and conflict mitigation). If that sounds like you, please find us through our

website ([www.earlycareercroc.net](http://www.earlycareercroc.net)) and apply to join.

We define the “early career stage” as that applying to people early in their career academically and non-academically, who are trying to run their projects under the niche of research, education, and conservation. Early career is not age-dependent but experience-dependent. People who are less experienced (less than 8 years in the field) in comparison to well-established individuals (8+ years in the field). We try to get well-established individuals to give talks to the ECCN members, and try to make a bridge between established individuals to share their knowledge and guidance to the newcomers in the field that encourages them to work on crocodylians.

If you are not-so-early career but would be happy to give an expert talk or panel session in the future, we would be delighted to host you, so please get in touch by e-mail ([earlycareercrocnetwork@gmail.com](mailto:earlycareercrocnetwork@gmail.com)). We are especially keen to reach out to students and individuals in Asia to participate in this network. We would be grateful if you are a CSG member from Asia and could be able to highlight this opportunity to students and early-career professionals working with crocodylians, who you may know.

Phoebe Griffith ([phoebe.griffith@zsl.org](mailto:phoebe.griffith@zsl.org)) and Brinky Desai ([brinky.d@ahduni.edu.in](mailto:brinky.d@ahduni.edu.in)), *Early Career Crocodile Network for Asia* ([earlycareercrocnetwork@gmail.com](mailto:earlycareercrocnetwork@gmail.com)).

## India

STATUS OF *CROCODYLUS PALUSTRIS* IN KUTCH DISTRICT, GUJARAT, INDIA. The Mugger (*Crocodylus palustris*) population in the state of Gujarat was previously estimated to comprise around 1500 individuals (Vyas 2013), and increasing (De Silva and Lenin 2010). Based on a 1997 survey at a limited number of sites, the Kutch district of Gujarat (Fig. 1) was reported to have an estimated total population of 176 Muggers (Vyas and Stevenson 2017). The Kutch district is the largest in India, with an area of 45,674 km<sup>2</sup>, and with an arid environment with very little regular rainfall and frequent droughts (Pai *et al.* 2014).

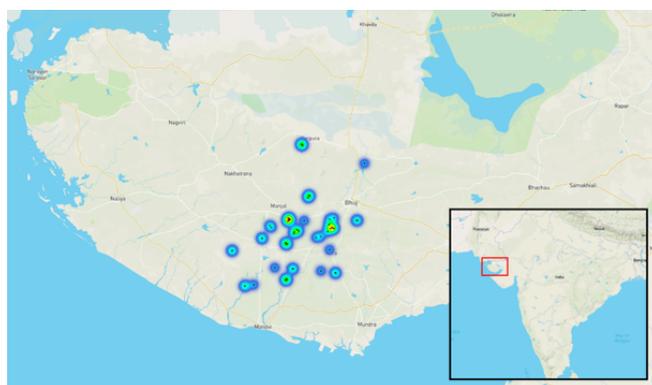


Figure 1. Kutch district, with hotspots denoting the largest crocodile populations.

There had been no systematic investigation or research on

Muggers in Kutch since 1999. Between 2012 and 2020 we conducted regular observations of various crocodile populations in central Kutch. We conducted surveys at various “known” crocodile sites to gather new data, and also investigated previously unexplored crocodile habitats.

In 2018, we started augmenting our ground surveys with a “DJI Phantom 4 Pro v2”, a widely used drone. We hoped that frequent medium-low altitude flights would help us get a better estimate of the populations than ground surveys alone, as the geography would not always allow for clear observations without disturbing the animals (Figs. 2 and 3). Drone flights also revealed several previously unrecorded water bodies supporting crocodile populations that were virtually inaccessible by foot. An additional advantage of aerial surveys is the higher subsurface visibility from the incident light angle, which allows for better detection of partially, and sometimes completely, submerged crocodiles, depending on the turbidity of the water. We surveyed connected water bodies with multiple flights at different times of the day and within a maximum period of 4 days to prevent data inaccuracies from minor migrations.



Figure 2. Muggers detected in a portion of observation map created from a drone flight.



Figure 3. Larger sites, such as Nara Dam, required drones for effective surveys.

One of our secondary goals was to create methods of drone observation that allow getting relatively close to crocodiles

without disturbing them. These methods have allowed us to not only get higher accuracy while counting, but also to approach crocodiles in remote places to examine them visually and assess their physical condition (Fig. 4). These methods have also been useful in providing preliminary data for dorsal scute pattern-based identification (Mukherjee *et al.* 2020). Some of our observation and process videos were annotated and included in the CSG Virtual UAS Workshop 2020 (<http://www.iucncsg.org/pages/Virtual-UAS-Workshop.html>) and additional footage is available on YouTube (<http://youtube.com/pandhiorg>).



Figure 4. Low-altitude sighting of a Mugger from a drone, and which was not visible from the ground.

Based on the findings from these flights and exploration on the ground, we decided on a list of potential sites for a large-scale survey covering the majority of Kutch’s habitable areas. We presented the plan to the Forest Department, which was keen to expand its data on this protected species, as well as use this opportunity for spreading awareness about Muggers.

In cooperation with the Kutch (West) Forest Division, we organized a citizen science initiative to carry out the first wide-scale crocodile survey of the region. We invited anyone interested in the initiative to volunteer, and more than 200 citizens volunteered from across the state. From these, 120 volunteers were chosen based on local COVID-19 regulations and logistic limitations. A high proportion of the volunteers comprised seasoned naturalists, zoology students from Kutch University, and experienced wildlife enthusiasts. We were pleasantly surprised to find several dozen volunteers were ordinary citizens from various walks of life with very little or no prior experience with crocodiles, including engineers, dentists, programmers, air force personnel and businessmen. Over 20 Forest Department personnel also participated in the survey. Volunteers were trained in observation and documentation techniques and taught how to approach crocodile habitats with both their and the animals’ safety in mind.

Although our projects suggested that there were over 250 crocodile sites in Kutch, we restricted surveys to 186 sites; 120 sites based on our active map of crocodile habitats and recent documented activity, and an additional 66 sites based on Forest Department recommendations (Fig. 5). Manpower limitations, logistics and safety concerns were also taken into account in deriving this initial list of sites. Water bodies in this region usually dry out within a month or two of rainfall, as winter temperatures during the day are quite high (>30°C). Most smaller water bodies tend to dry out by October.

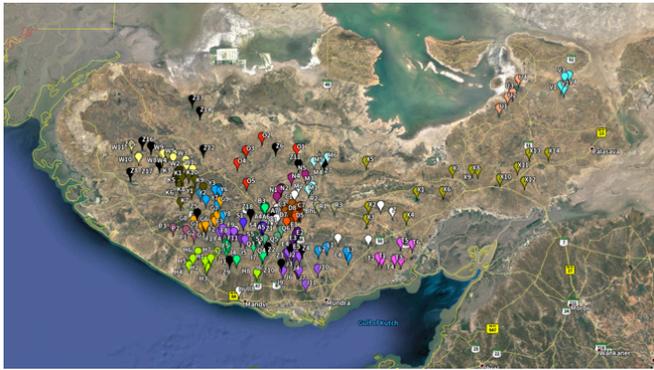


Figure 5. Sites designated for the Crocodile Status Survey.

The survey was carried out in late-February 2021, primarily during the day to conform to COVID-19 regulations. The volunteers were divided into teams and assigned individual site clusters. Most sites were surveyed once, but 13 key sites were surveyed multiple times within that week to correct any irregularities in sightings or to clarify ambiguous data, and 20 key sites were also surveyed by drone for additional accuracy or if they were too difficult to reach on foot.

Volunteers submitted extensive photographic and video evidence of observations, habitat details, and elements related to potential or active conflict. Over 1TB of data was collected from the survey, which was sifted and verified by our team and Forest Department personnel. Our team at the Mahim Pandhi Wildlife Foundation created custom software applications to analyze the collected data as well as drone observations. This data will also be used to seed further aerial automation methods for observations and surveys.

Table 1. Results of surveys. Totals (N= 113) refers to those sites recorded as containing Muggers.

Division	No. of Sightings	No. of Sites	Area (km <sup>2</sup> )	Rel. Density (ind./km <sup>2</sup> )	Mean Ind./site
Bhuj	236	60	5936	0.040	3.9
Mandvi	125	27	1573	0.079	4.6
Nakhatrana	33	12	2135	0.015	2.8
Abdasa	9	8	2535	0.004	1.1
Mundra	5	6	1098	0.005	0.8
<b>Totals</b>	<b>408</b>	<b>113</b>	<b>13,277</b>	<b>0.031</b>	<b>3.6</b>
<b>Totals</b>	<b>408</b>	<b>163</b>	<b>22,196</b>	<b>0.018</b>	<b>2.5</b>

Results of surveys are summarized as:

1. A total of 408 crocodiles was sighted at 113 of the 186 sites surveyed (Table 1), and no crocodiles were sighted at 50 sites (23 sites were considered non-viable because of recent human interference such as excavation for building materials or aggressive water pumping by nearby farms).
2. Relative density was 0.031/km<sup>2</sup> for the 113 sites at which Muggers were sighted. Including the 50 sites at which none were sighted, the overall relative density for 163 sites was 0.018/km<sup>2</sup> (Table 1).
3. Numbers of Muggers per site varied between 0 and 180 (mean= 2.5/site, N= 163 sites), with the largest population (180) recorded in Pragsar Lake at Chadva Rakhaal.
4. An additional 421 Muggers were reported from survey sites, based on multiple sources of information, including local naturalists, wildlife enthusiasts, residents at various sites who have encountered the crocodiles first-hand, and Forest Department staff who cover these sites in their regular duties.
5. Approximately 60% of sightings were in small ponds. Larger populations were found only in dams and reservoirs, as Kutch has no perennial rivers.
6. 30% of crocodiles were within 1 km of human settlements, while 7% were residing within settlements themselves.
7. According to Forest Department records, there have been no human fatalities recorded in several decades. Kutch has the lowest number of human-crocodile conflicts (Vyas and Stevenson 2017) in Gujarat. While there are a high number of Muggers rescued every monsoon and summer, actual attacks on humans and fatalities have not been recorded. One “fatality” recorded in the past 20 years, was later determined by the Forest Department to be a natural death after examination of the body. Inversely, there are frequent crocodile deaths on roads and railways (Vyas and Vasava 2019).
8. Muggers of Kutch have shown a remarkably low level of aggression relative to their counterparts on mainland Gujarat, Tamil Nadu, etc. This observation has been confirmed by people who live near crocodile habitats, as well as Forest Department personnel who work with crocodile rescue and release. We found that most people living near crocodile habitats, or where crocodiles lived within central village ponds, were quite tolerant of the animals and did not consider them a danger or a nuisance (Fig. 6).
9. At least 54% of sites were polluted with plastic waste (Fig. 7) and 36% of sites had unsafely discarded industrial materials. Some residents near a river that hosts over 30 crocodiles claimed that it was a dumping ground for a chemical company. Many crocodile populations that are near or sometimes within temples, or near settlements built around temples, are exposed to very high levels of pollution, especially plastic refuse and small statues and

idols often painted with paint containing lead.



Figure 6. Fisherman spreading a net as a crocodile swims nearby. This water body contained 16 adult Muggers.



Figure 7. Muger observed repeatedly biting a plastic bag.

10. 44% surveyed sites were within 500 m of wind turbines. In central Kutch, effective areas for wind turbines seem to intersect deeply with the largest clusters of crocodile populations. In the 12+ months since the survey, an additional 40 turbines and associated service roads were constructed in this region. We have recommended further study of these areas and the impact of wind turbine installations on the habitat, as well as the potential for conflict, to the authorities.
11. Kutch is seeing accelerated growth, which in turn is causing large-scale, aggressive habitat loss for wildlife; 62% of surveyed sites were within 500 m of ongoing construction.
12. Water is a hotly contested commodity in this arid region. Farmers near ponds and reservoirs employ aggressive, unregulated water pumping. This leads to early depletion of the water bodies ahead of the dry season. At least 25% of surveyed sites had at least one water pump.
13. Feral dogs were routinely observed, both during the survey (at 49% of surveyed sites; Fig. 8) and in our observations over the last 6 years, to predate on crocodile nests and hatchlings as they get better access from the plummeting water levels.



Figure 8. Feral dog preparing to attack a juvenile Muger.

## Conclusions

The Muger population in Kutch district is estimated to be around 1000 individuals, which is significantly higher than the previous 1997 estimate of 176 animals (Vyas and Stevenson 2017). However, crocodiles and their habitat remain vulnerable. We believe there are at least 50 additional sites that need to be investigated, especially closer to the desert.

The survey also indicated widespread destruction of crocodile habitats. We intend to repeat the survey at regular intervals, and are currently investigating additional sites and data points to increase the efficacy of the next survey.

Authorities are using the survey data to improve protection of crocodile habitats and rescue and release operations. Data from the survey has also been useful for broader conservation efforts for crocodiles (Mobaraki *et al.* 2021), as well as our own ongoing behavioural studies. We hope to share results from these studies in the near future.

## Acknowledgements

We would like to thank the Kutch (West) Forest Division and Deputy Conservator of Forests Dr. Tushar Patel, for their cooperation and extensive support, the Forest Department staff for providing additional data, observations, and relevant information from patrols and rescues, and all the volunteers who helped execute this survey. We would also like to thank Rom Whitaker, Nikhil Whitaker and Madras Crocodile Bank and Trust for their support, guidance, and encouragement.

## Literature Cited

- De Silva, A. and Lenin, J. (2010). Muger Crocodile *Crocodylus palustris*. Pp. 94-98 in Crocodiles. Status Survey and Conservation Action Plan. Crocodile Specialist Group: Darwin, Australia.
- Mobaraki, A., McCaskill, L., Schepp, U., Abtin, E., Masroor, R., Pandhi, D., Desai, B., Mukherjee, S., Rasheed, T., Razzaque, S.A., de Silva, A., Stevenson, C., Rauhaus, A., Le, M.D., Rödder, D. and Ziegler, T. (2021). Conservation

status of the Mugger (*Crocodylus palustris*): Establishing a task force for a poster species of climate change. Crocodile Specialist Group Newsletter 40(3): 12-20.

Mukherjee, S., Ghosal, R., Datt, M. and Desai, B. (2020). Preliminary assessment of use of dorsal scute patterns to identify wild muggers in human-dominated landscapes of central Gujarat, India. Crocodile Specialist Group Newsletter 39(2): 15-18.

Pai, D.S., Rajeevan, L.S.M., Sreejith, O.P., Satbhai, N.S. and Mukhopadhyay, B. (2014). Development of a new high spatial resolution long period (1901-2010) daily gridded rainfall data set over India. MAUSUM 65(1): 1-18.

Vyas, R. and Stevenson, C. (2017). Review and analysis of human and Mugger crocodile conflict in Gujarat, India from 1960 to 2013. Journal of Threatened Taxa 9(12): 11016-11024.

Vyas, R. and Vasava, A. (2019). Mugger crocodile (*Crocodylus palustris*) mortality due to roads and railways in Gujarat, India. Herpetological Conservation and Biology 14(3): 615-626.

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REVIVAL OF NATURAL BREEDING OF GHARIAL (*GAVIALIS GANGETICUS* GMELIN, 1789). Odisha is the only state of India with all three species of crocodylian; Gharial (*Gavialis gangeticus*), Mugger (*Crocodylus palustris*) and Saltwater crocodile (*Crocodylus porosus*). The Mahanadi is one of the major rivers of India, and the southernmost distribution of the critically endangered Gharial. Once found throughout the entire Mahanadi River, only five Gharials (2M: 3F) were sighted in a survey in 1974, in the Satkoshia Gorge, lapped between the Eastern Ghat Hill Range on its south and Chhotanagpur Plateau on the north. To conserve the Gharials, a rearing centre was established at Tikarpara and a captive breeding centre at Nandankanan Biological Park, Bhubaneswar, in 1975.

From 1977 to 2017, 860 Gharials were released into the Mahanadi River, but survival was disappointing, with only 8 Gharials being recorded in 2018-19. The major threats to survival appear to have been deleterious fishing activities, disturbed habitat, and perceived interspecific conflict between Gharials and Muggers (Maharana and Mohapatra 2021).

At present, five Gharial subpopulations [Chambal River; Katerniaghat Reservoir (Girwa River); Chitwan National Park, Nepal; Corbett National Park; Gandak River) are breeding in the wild, and nesting of the subpopulation in Bardia National Park (Nepal) is expected in the future. The Gharial population of the Mahanadi River was included as one of eight minor sites with no evidence of breeding in the recent past (Lang *et al.* 2019).

Tikarpara rearing centre ceased producing hatchlings by 1981 and Nandankanan Biological Park continued breeding and releasing Gharial into the Mahanadi River, but there arose a need to rethink the release program in 2019. A new project named "Species Recovery of Gharial (*Gavialis gangeticus*, Gmelin) in the River Mahanadi" was implemented with stricter conservation measures. This ambitious project was conceptualized and commissioned in July 2019 (Paul 2019). It has provision for an updated assessment of Gharials in the Mahanadi River and evaluation of problems affecting their survival. The present situation demanded some unprecedented steps, with the involvement of 10 Divisional Forest Officers on either side of the Mahanadi River, from the Hirakud Dam to the Bay of Bengal, for: rigid protection; enforcement of a "No Fishing Zone" in 10 km of Gharial habitat in the Satkoshia Gorge where the present Gharial population exists; spreading awareness among local people; provision of compensation for damaged fishing nets; reward of Rs. 1000 on return of live Gharial caught in nets; and, a comprehensive study of river physiography, Gharial ecology, and monitoring of dispersal and survival of transmitter-fitted Gharials.

The last Gharial nest in Satkoshia Gorge was recorded in 1981, 2 km downstream of the Tikarpara rearing centre at Ramagaonbali, on the left bank of the river. The nest was found open with broken egg shells, and with no evidence of hatchlings. With implementation of the project and stated interventions, the habitat at Satkoshia Gorge became amenable for Gharial breeding. Courtship was observed in November and December of 2019 and 2020, that resulted in 28 hatchlings from 28 eggs in one nest on 22 May 2021 (Fig. 1).



Figure 1. Excavated nest, female Gharial and hatchlings in the Mahanadi River. Photograph: R.K. Mohapatra.

The first female Gharial to breed in captivity, in 1980 at Nandankanan Biological Park, laid 25 eggs (Bustard and Maharana 1980, 1985), compared to the wild Gharial in 2020 that laid 28 eggs. The wild nest was located in sand on the left (northern) bank of the Mahanadi River, 13.5 m away from the water's edge, at a height of 7 m from the water surface. Its circumference was 2.5 m, and depth of the excavated nest was 70 cm, and contained roots of nearby trees (*Barringtonia*

Table 1. Details for Gharial hatchlings that dispersed downstream of their nest site on the Mahanadi River after hatching on 21 May 2021. See Figure 2 for locations.

No.	Date Retrieved	Location	Distance from nest site (km)	Length and weight at retrieval
1	6 August 2021	Barada, Cuttack; Mahanadi River	151	52.5 cm 175 g
2	29 August 2021	Samjori, Kendrapada; Paika River	206	58.5 cm 230 g
3	22 October 2021	Chhoti, Kendrapara; Birupa River	195	82.0 cm 780 g

*acutangula*, *Syzygium cumini*). Wild shrubs of *Chromolaena odorata* were near the nest. The 2.5 m long female Gharial does not appear to be a “release animal”, and was observed guarding the hatchlings against intruders, including a Mugger (Fig. 1).

The breeding of this Gharial in the Mahanadi River after 40 years is an assurance for survival of the species in its southernmost habitat. In view of the unsuccessful establishment of released Gharials over the years, the hatchlings were left in the wild so as to study their dispersal. They stayed with the female for a month and then started dispersing downstream (Fig. 2), with three of them were located 151 km, 206 km and 195 km, respectively, from the nest site (Table 1).



Figure 2. Dispersal of Gharial hatchlings from nest site in the Mahanadi River. See Table 1 for details.

#### Acknowledgements

We acknowledge Divisional Forest Officers of Satkosha (Wildlife) and Mahanadi (Wildlife) Division for the implementation of conservation measures in Satkosha Gorge. We are thankful to the Divisional Forest Officers of Cuttack and Mangrove Forest Division, Rajnagar, for retrieval of Gharial hatchlings. L.P. Rath and A. Khan deserve thanks for their help in field study.

#### Literature Cited

- Bustard, H.R. and Maharana, S. (1980). First captive breeding of the gharial (*Gavialis gangeticus*). *British Journal of Herpetology* 6(3): 106.
- Bustard, H.R. and Maharana, S. (1985). Captive breeding of the gharial (*Gavialis gangeticus*). *Association for the Study of Reptilia and Amphibia Journal* 2(4): 23-45.

Lang, J., Chowfin, S. and Ross, J.P. (2019). *Gavialis gangeticus*. The IUCN Red List of Threatened Species 2019: e.T8966A3148543.

Maharana, S. and Mohapatra, R.K. (2021) Interspecific conflict between Gharial (*Gavialis gangeticus*) and Mugger (*Crocodylus palustris*) in the Mahanadi River, Odisha, India. *Crocodile Specialist Group Newsletter* 40(2): 7-8.

Paul, S. (2019). Species recovery of gharial (*Gavialis gangeticus*, Gmelin) in river Mahanadi. Project Proposal of Director, Nandankanan Biological Park, Forest, Environment and Climate Change Department, Government of Odisha, India.

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LIMB DEFORMITIES IN THE POPULATION OF ESTUARINE CROCODILES, *CROCODYLUS POROSUS*, IN BHITARKANIKA NATIONAL PARK, ODISHA, INDIA. During a 46-year study of Estuarine crocodiles (*Crocodylus porosus*) in the river systems and associated habitats of Bhitarkanika National Park (BNP), including the annual winter population census (eg Kar and Bustard 1989, 2021, 2022), five male crocodiles with leg deformities have been sighted. Photographic evidence and descriptions of the deformities have been documented, and are outlined here.

Case 1: Limb deformation in a male *C. porosus* (approx. 4.3 m TL) was described by Kar (2020) (Fig. 1). The femur of the left hindlimb appeared to be completely missing (or greatly reduced in size), and the tibia-fibula portion of the limb attached directly to the body.

Case 2: Deformation of right hindlimb of a male *C. porosus* of about 4 m TL (Fig. 2). The femur and tibia-fibula portion of the limb appear to be merged and attached directly to the body. The other limbs appeared normal.

Case 3: Deformities in the left forelimb and left hindlimb were observed in a male *C. porosus* of about 3.9 m TL (Fig. 3). The hindlimb appeared to be swollen and mis-shapen.

The crocodile was unable to maintain its limb properly along with the body (Fig. 3). It appeared that the hindlimb was not functional. In the forelimb, the radius-ulna bones are largely missing or reduced to a great extent, but the humerus appeared to be fully developed. Fingers in the limb are underdeveloped and rudimentary.



Figure 1. Approximately 4.3 m *C. porosus* with left hindlimb deformity. Photograph: Sudhakar Kar.



Figure 2. Approximately 4 m *C. porosus* with right hindlimb deformity. Photograph: Nimai Bhakta.



Figure 3. Approximately 3.9 m *C. porosus* with left fore- and hindlimb deformities. Photograph: Nimai Bhakta.

Case 4: A 4.2 m male *C. porosus* is having deformed right forelimb (Fig. 4). The humerus bone seemed to be developed but radio-ulna bone is missing or it is extremely rudimentary. Other three limbs are fully functional. The anterior portion of the right lower jaw front portion appeared to be injured, and a

couple of teeth were missing.



Figure 4. Approximately 4.2 m *C. porosus* with right forelimb deformity. Photograph: Sudhakar Kar.

Case 5: This is one of the largest (and oldest?) male *C. porosus* (approx. 6 m TL) in BNP (Fig. 5). It has a deformed left forelimb, where the radius-ulna portion appearing to be rudimentary and with loss of shape. The carpal and metacarpal are perhaps fused together. Strangely, nails were not visible.



Figure 5. Approximately 6 m *C. porosus* with left forelimb deformity. Photograph: Nimai Bhakta.

The recorded deformities among these adult male crocodiles are considered to be congenital in nature (Kar 2020; Webb and Messel 1977), rather than injuries. Although the position and morphology of the ‘deformed’ limbs suggest that they may be of limited use in water or on land, the crocodiles were observed emerging from the water onto the banks, presumably using the other ‘normal’ limbs. That these crocodiles have reach these “adult” sizes indicate that the deformities have not restricted their abilities to swim, feed, bask, etc. Interestingly, such deformities have not been reported from any known female *C. porosus* in the BNP population.

#### Acknowledgements

I am thankful to all Chief Wildlife Wardens, Odisha and Wildlife Wardens of the Mangrove Forests (Wildlife) Division, Rajnagar for extending support to study on Estuarine crocodiles in Bhitarkanika mangrove ecosystem since mid-1975.

#### Literature Cited

Kar, S.K. and Bustard, H.R. (1989). Status of Saltwater crocodiles (*Crocodylus porosus* Schneider) in Bhitarkanika Wildlife Sanctuary, Orissa, Journal of the Bombay Natural

History Society 86(2): 141-150.

Kar, S.K. (2020). Limb deformity of a male Estuarine crocodile (*Crocodylus porosus*) in Bhitarkanika National Park, Odisha, India. *Crocodile Specialist Group Newsletter* 39(3): 11.

Kar, S.K. (2021). Census of Estuarine crocodiles, *Crocodylus porosus* in the river systems of Bhitarkanika National Park, Odisha, India. *Crocodile Specialist Group Newsletter*. 40(1): 14-15.

Kar, S.K. (2022). Census of Estuarine crocodiles, *Crocodylus porosus* in the river systems of Bhitarkanika National Park, Odisha, India. *Crocodile Specialist Group Newsletter* 41(1): 10-11.

Webb, G.J.W. and Messel, H. (1977). Abnormalities and injuries in the estuarine crocodile, *Crocodylus porosus*. *Australian Wildlife Research* 4: 311-319.

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## Nepal

REINTRODUCTION OF GHARIALS IN THE KOSHI RIVER, KOSHI TAPPU WILDLIFE RESERVE, NEPAL. Koshi Tappu Wildlife Reserve (KTWR) is located at the southeastern Terai, the floodplains of the Saptakoshi River, which is snow-fed and originates in the Himalayas, and the largest river in Nepal. KTWR was gazetted with a core area of 175 km<sup>2</sup> in 1976, to preserve habitat for the only remaining population of Arna wild buffalo (*Bubalus arnee*), and in 2004 it was surrounded by a buffer zone of 173.5 km<sup>2</sup> area (Fig. 1). The eastern and western embankments of the Saptakoshi River define the area. The reserve is home to some of the rarest and endangered species of wildlife, including wild elephants, Arna, dolphin, fishing cats, python, Bengal florican, etc. In 1987, KTWR was declared a Ramsar site - a wetland of international significance. The Koshi River flows about 20 km braided among numerous channels within the core area of KTWR, and the Nepalese Army is deployed to protect the reserve.

Gharials (*Gavialis gangeticus*) are believed to have become extinct from the Koshi River in the 1970s (Maskey 1984). Releases of captive-bred Gharial were undertaken in the Koshi River in 1982 (N= 42), 1986 (N= 43) and 2010 (N= 10), but no Gharial were recorded there during the National Crocodile Survey in 2016. For this reason, on 2 February 2022, World Wetlands Day, 20 captive-reared Gharial were released into the Koshi River, within the KTWR jurisdiction. The formal release program involved the participation of the Chief of Madhesh Pradesh (Province), the Federal Minister of Forest and Environment, Ministers of the Province, the Director General of National Parks and Wildlife Conservation, the

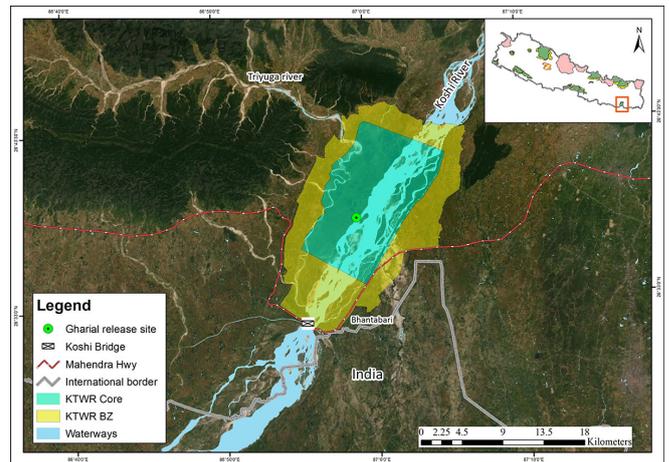


Figure 1. Koshi Tappu Wildlife Reserve, showing Gharial release site.

Warden of KTWR, representatives of WWF Nepal, National Trust for Nature Conservation, Zoological Society of London, Nepal (ZSL Nepal), and local politicians and leaders. The local fishing community was also invited to the event (Fig. 2).



Figure 2. Top: Officials (top) and local community (bottom) at Gharial release. Photographs: Bed Khadka.

The Gharials were released in the Moriyadhar tributary of the Koshi River, about 4 km east of KTWR's core area, and about 15 km from the Nepal-India border of Koshi Barrage

(Fig. 1). All Gharials were hatched in June 2017 at the Gharial Conservation Breeding Center in Chitwan National Park (Khadka 2020a). Before release, they were measured (TL, SVL), weighed, sexed and scute-clipped. The group comprised 2 males and 18 females [mean TL= 193.0 cm (range 174 to 213 cm); mean SVL= 109.2 cm (range 101 to 121 cm); mean weight= 19.1 kg (range 14 to 25 kg)].

The Gharials were transported within specially designed ventilated wooden boxes (26 x 32 x 222 cm; see Fig. 4) in a small truck over a distance of around 350 km - about a 10-hour drive. They were “soft released” into a temporary enclosure made of local grass and bamboo, with fresh water, fish and low water flow (Fig. 3), where they stayed for 5 days, at which time they broke through the enclosure and moved to the natural habitat of the river.



Figure 3. Temporary enclosure into which Gharial were initially released. After 5 days, they broke through into the adjacent river. Photograph: Bed Khadka.



Figure 4. Captive-reared Gharial being released at same release site on the Koshi River, in 2010. Photograph: Bed Khadka.

The failure of previous reintroductions (Fig. 4) in the Koshi River is considered to be due to lack of food and proper protection arrangements. These challenges are now being addressed by focusing on management strategies for expansion of KTWR area, strengthening institutional capacity

of KTWR, conducting alternative livelihood programs for local communities dependent on wetlands, regulation of river materials collection, ban on use of certain types of fishing nets, and initiatives for construction of crocodile-friendly fish ladder at Koshi Barrage.

We believe that high proportion of GCBC-released Gharials travel downstream to India (Khadka 2020b; Griffith *et al.* 2020). According to short survey by Nair *et al.* (2019), a few Gharials survive in different parts of the Koshi River system in India, and they could potentially be released Gharials from Nepal. A sub-adult Gharial rescued in 2018 in the Koshi River near Sitapur village (India), near the Nepal-India border, had scute-clipping resembling the pattern/coding system used in Nepal.

Ecotourism activities in the region are expected to accelerate after the restoration of endangered Gharials in the Koshi River. This is the beginning of an effort of cooperation, collaboration and coordination between the local, provincial and federal Governments in the recovery and conservation of key wildlife species in Nepal.

#### Literature Cited

Griffith, P., Khadka, B.B., Basnet, P. and Bhatta, R. (2020). Gharial telemetry research in Chitwan National Park, Nepal. Update 2019-2020. Crocodile Specialist Group Newsletter 39(2): 22-24.

Khadka, B. (2020a). Gharial Conservation Breeding Center in Chitwan National Park: Contribution, challenges and opportunities. Crocodile Specialist Group Newsletter 39(4): 19-21.

Khadka, B. (2020b). Gharial travel more than 1000 km from Nepal to India. Crocodile Specialist Group Newsletter 39(2): 20-21.

Nair, T., Day, S. and Gupta, S.P. (2019). Short survey for Gharials in the Koshi River, India. Crocodile Specialist Group Newsletter 38(4): 11-14.

Maskey, T.M. (1994). Survey of Koshi, Kali Gandaki and Narayani Rivers in Nepal. DNPWC: Kathmandu, Nepal.

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CROCODILE CAPTURE, HANDLING AND RELEASE TRAINING IN CHITWAN NATIONAL PARK, NEPAL. In Nepal, during the rainy season (June-August), Gharial (*Gavialis gangeticus*) and Mugger (*Crocodylus palustris*) will tend to move out of swift-flowing rivers such as the Narayani and Rapti Rivers in Chitwan National Park (CNP), and into areas outside of these mainstream river habitats. Occasionally crocodiles may also be swept by floodwaters

into paddy fields. During the monsoon and post-monsoon seasons, Muggers have been observed approaching fishponds, which in CNP are typically situated in paddy fields near paddy streams. Gharials do not typically enter fishponds, but

will stay in small tributary streams.

The entry of Muggers into fishponds has increased the frequency of human-crocodile conflict (HCC), and



Figure 1. Practical session involving capturing Gharial (left), and taking morphometric measurements before release of an adult Gharial (right). Photographs: Bed Khadka.



Figure 2. Participants releasing captive-raised Gharials. Photographs: Bed Khadka.

Table 1. Crocodiles rescued in Chitwan National Park, January-December 2021. GCBC= Gharial Conservation Breeding Center.

Rescue Location	Gharial	Mugger	Guard Post	Notes
Kawasoti-15	1	-	Amaltari	Entangled in fishing gillnet
Kawasoti-17	-	2	Amaltari	
Madhyabindu-15	-	1	Amaltari	
Chhitamai, Rapti River	1	-	GCBC	Entangled in fishing gillnet
Devnagar Village	-	3	GCBC	
Kasara, Rapti River	4	-	GCBC	Entangled in fishing gillnet
Kerunga	1	-	GCBC	Entangled in fishing gillnet
Jagatpur Village	-	4	GCBC	
Pargati nagar	1	-	Kujauli	In canal
Khairahani-10, Kushana	1	-	Pyaridhap, Khagendramali	Stranded in small paddy channel
Rapti Municipality-5, Hatani Tol	-	1	Pyaridhap, Khagendramali	
Rapti Municipality-6, Gharial Pokhari	-	1	Pyaridhap, Khagendramali	
Rapti Municipality-6, Laugain	-	1	Pyaridhap, Khagendramali	
Rapti Municipality-6, Phulbari	-	1	Pyaridhap, Khagendramali	
Rapti Municipality-10	-	1	Pyaridhap, Khagendramali	
Rapti Municipality-10, Kushana	-	1	Pyaridhap, Khagendramali	
Buspark, Sauraha	1	-	Sauraha	Stranded in small paddy channel
Bastha Village	-	1	Siswar	
<b>Total</b>	<b>10</b>	<b>17</b>		

sometimes Gharial at nearby streams may suffer mortality due to perceived HCC of local people. Thus, CNP authorities face challenges to conserve Gharials and Muggers residing in these “temporary” habitats. In addition, Gharials may also become entangled in legal fishing nets (CNP issues fishing licenses to communities).

Realizing this situation, a hands-on training course on crocodile capture, handling and release was conducted for 19 frontline CNP staff on 1-3 January 2021. Participants were selected from park posts along the rivers, and where HCC occurs. The training included: preparation during crocodile rescue operations; field rescue operations in private fishponds and rivers (eg capture, handling and release); and, communication within rescue teams. The course involved hands-on rescue and release of wild Gharial in the Rapti River (Fig. 1) and release of captive Muggers (Fig. 2). The authors, Bed Bahadur Khada and Santosh Bhattarai, delivered the training.

Following the training session, participants were involved in rescue operations of crocodiles at their respective duty stations (Table 1). The training was intended to create a rapid rescue team for crocodiles and reduce HCC, and so far the effect of the training has been very positive, and beneficial to crocodile conservation and management efforts in CNP.



Figure 3. Participants of training session. Photograph: Santosh Bhattarai.

#### Acknowledgements

The training was organized at the Gharial Conservation Breeding Center, Chitwan National Park. Financial support for the training was provided by Darwin Initiative, ZSL Nepal, through the National Trust for Nature Conservation (NTNC). We would like to thank staff of the Chitwan National Park office and NTNC Chitwan for logistic support.

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## West and Central Africa

### Ghana

EMMANUELLE AMOAH WINS WHITLEY AWARD. In April 2022, Emmanuelle Amoah, from Ghana, was one of six scientists recently awarded a Whitley Award (WFN 2022a). The Whitley Awards are flagship prizes of the Whitley Fund for Nature (WFN), a UK fundraising and grant-giving charity, which supports conservation leaders working in their countries across the Global South. The Whitley Awards are won competitively following assessment by an expert academic panel, and worth £40,000 in project funding over one year.



Figure 1. Emmanuelle Amoah receiving Whitley Award from HRH Princess Royal, patron of the Whitley Fund for Nature. Photograph: Whitley Fund for Nature.



Figure 2. Emmanuelle Amoah tracking crocodiles. Photograph: Threatened Species Conservation Alliance.

Emmanuelle, a CSG Regional Vice Chair for the West-Central African region, and his team, are working with the African Slender-snouted crocodile (*Mecistops cataphractus*), to expand work with communities, restore critical habitats and raise conservation awareness. Specifically, they will aim to: reduce vegetation loss on riverbanks where this species nests by at least 40% in 4 communities; train 14 conservation champions across 4 communities to monitor threats and

dovetail with awareness raising to halve illegal logging activities; and, replant 30 ha of degraded nesting habitat to boost crocodile breeding success (WFN 2022b).

We congratulate Emmanuelle on winning this prestigious award, and look forward to seeing the results of his work.



Figure 3. Community education. Photograph: Threatened Species Conservation Alliance.

#### Literature Cited

WFN (2022a). Announcing the 2022 Whitley Award winners! (<https://whitleyaward.org/2022/04/28/announcing-the-2022-whitley-award-winners/>).

WFN (2022b). Tales from the riverbank: Safeguarding the last stronghold of the West African Slender-snouted crocodile. (<https://whitleyaward.org/winners/tales-from-the-riverbank-safeguarding-the-last-stronghold-of-the-west-african-slender-snouted-crocodile/>).

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## North America

### USA

The Winter 2021 edition of the Louisiana Conservationist focused on the American alligator (*Alligator mississippiensis*). The alligator is an important part of Louisiana's economy, with the industry valued at around \$US250 million per annum. The management of the alligator is certainly a success story, with the species in Louisiana recovering from around 100,000 individuals in the 1960s, to around 2 million today. Sustainable use of this valuable resource has been the basis of the management of the species, and Louisiana's experiences have benefitted other crocodylian species in other countries.

Relevant articles in this issue of the Louisiana Conservationist are:

- Iles, T. (2022). Gator handlers. Thanks to LDWF the species is thriving in Louisiana. Louisiana Conservationist 72(4): 2-5.
- Elsey, R. (2022). Alligator abode. Coastal marshes provide the home for most Louisiana alligators. Louisiana Conservationist 72(4): 7-10.
- Elsey, R. (2022). Examining alligators. LDWF's extensive research has helped bring back the alligator. Louisiana Conservationist 72(4): 11-15.
- Iles, T. (2022). DON'T feed the gators! Alligator biologists say it's the best way to avoid alligator/human conflicts. Louisiana Conservationist 72(4): 20-21.
- The Alligator Cookbook (2022). Louisiana on your plate. Several alligator recipes from "The Alligator Cookbook". Louisiana Conservationist 72(4): 31.
- Palmisano, A.W. (2022). Times gone by. The Alligator: A wildlife resource in Louisiana. Louisiana Conservationist 72(4): 32.

This issue of the Louisiana Conservationist is available at: <https://online.fliphtml5.com/obxht/hstj/#p=1>.



### Recent Publications

Eversole, C.B. and Henke, S.E. (2022). Wetland habitat characteristics predict nest site selection of American alligators (*Alligator mississippiensis*) in an inland freshwater ecosystem. Herpetologica (<https://doi.org/10.1655/Herpetologica-D-21-00024>).

Abstract: Habitat characteristics can have large effects on nest site selection of oviparous vertebrates. It is thought that habitat preference in many species is driven by natural selection because of habitat-specific fitness consequences. However, long-term studies on nesting of oviparous reptiles, in particular, are less common in comparison with other nesting vertebrates. As a result, specific habitat associations that define nesting habitat for many species are largely unknown. We studied habitat characteristics and selection of American alligator (*Alligator mississippiensis*) nest sites in inland freshwater wetlands. We investigated the habitat characteristics associated with 112 nests studied during the 2013-2019 nesting seasons, and quantified habitat characteristics in relation to nest locations and random points. A nearest neighbor analysis indicated that American alligator nests are not randomly distributed across wetlands, but are more representative of a clumped spatial distribution, suggestive of habitat preference and site selection. We measured habitat variables such as wetland vegetation cover, average water depth, island density, bank slope, canopy cover, and wet bulb globe temperature, as well as alligator population demographics such as relative adult proportion, at each nest and random site. Subsequently, we found that the best variables for predicting American alligator nest site selection included island density, slope of bank, canopy cover, and wet bulb globe temperature. The best predictive model demonstrated that the odds of nest site selection increased with increasing canopy cover, wet bulb globe temperature,

island density, and decreasing bank slope. These habitat choices presumably reduce the risk of nest predation and provide thermal cover for proper balance of nest site microclimate. Based on our results, practices focused on alligator nesting habitat should consider these specific habitat characteristics in outlining applied strategies and working toward management and conservation goals.

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Gutiérrez-Cervantes, A., Ahuja-Aguirre, C., López-deBuen, L. and Viveros-Peredo, S. (2022). Blood cell morphology and leukocyte differential of Morelet's crocodile (*Crocodylus moreletii*) (Crocodylidae). *Acta Biológica Colombiana* 27(1): 17-27.

**Abstract:** The objective of the study was to determine the morphological characteristics of peripheral blood cells (erythrocytes, leukocytes, thrombocytes) and the leukocyte differential count (heterophils, eosinophils, basophils, lymphocytes, monocytes, azurophils) of captive Morelet's crocodiles (*Crocodylus moreletii*) from Veracruz, Mexico. Peripheral blood from 80 apparently healthy farmed crocodiles (39 sub-adults [19 females, 20 males] and 41 adults [18 females, 23 males]) was examined for morphology through stained blood smears and manual count was used for the leukocyte differential. Blood was collected during the non-breeding (n= 42) and breeding (n= 38) seasons. Blood examination indicated similar morphological characteristics of blood cells in sub-adult and adult individuals and in females and males in both seasons. Erythrocytes were the largest blood cells and lymphocytes the smallest. The leukocyte differential count showed that lymphocytes were the most abundant leukocytes and basophils the least numerous. The percentages of some leukocytes showed difference by season (non-breeding and breeding) in sub-adult and adult males (p<0.05) and by size (sub-adults and adults) in males and females but only in the non-breeding season (p<0.05). The leukocytes that showed the greatest variation were lymphocytes, heterophils and eosinophils. The knowledge of blood cell morphology and the leukocyte differential count in healthy farmed Morelet's crocodiles will allow the accurate diagnosis of some diseases of captive and wild individuals

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Starck, J.M. and Wyneken, J. (2022). Comparative and functional anatomy of the ectothermic sauropsid heart. *Veterinary Clinics of North America: Exotic Animal Practice* 25(2): 337-366.

**Abstract:** The hearts of sauropsids initially develop similarly from an embryonic tube that loops on itself and during that process forms the 2 atria and the ventricular partitions. The sinus venosus remains and the embryonic outflow tract, the truncus arteriosus, becomes organized as the visceral arches. The particular outflow tracts of crocodilians and birds primarily differ from that of other sauropsids in which visceral arches contribute to each and in the formation of a complete interventricular septum. The ventricles of lizards, snakes, and turtles have partially separated but communicating chambers within the ventricle that can allow mixing of blood. Crocodilians have a complete intraventricular septum to form a 4-chambered heart, with 2 aortae to the body and a pulmonary trunk to the lungs. In contrast, birds have a 4-chambered heart with a right aorta to the body and a pulmonary trunk to the lungs. Squamates and chelonians have intracardiac shunting capacity. Shunting in crocodilians may occur outside the heart via the Foramen of Panizza. Pythons and at least some varanid lizards have a well-developed muscular ridge that allows some functional separation of blood flow within the ventricle (but also intracardiac shunting). The physiologic implications are the capacity to sustain higher systemic blood pressures and higher metabolic rates than other squamates.

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Schachner, E.R., Diaz, R.E., Coke, R., Echols, S., Osborn, M.L. and Hedrick, B.P. (2022). Architecture of the bronchial tree in Cuvier's dwarf caiman (*Paleosuchus palpebrosus*). *Anatomical Record* 2022: 1-18.

**Abstract:** We imaged the lungs of five Cuvier's dwarf caiman (*Paleosuchus palpebrosus*) via computed tomography (CT) and micro-computed tomography ( $\mu$ CT) and compared these data to the lungs of the American alligator (*Alligator mississippiensis*). These data demonstrate anatomical commonalities between the lungs of *P. palpebrosus* and *A. mississippiensis*, and a few notable differences. The structural similarities are: (a) a proximally narrow, distally widened, hook-shaped primary bronchus; (b) a cervical ventral bronchus that branches off the primary bronchus and immediately makes a hairpin turn toward the apex of the lung; (c) a sequential series of dorsobronchi arising from the primary bronchus caudal to the cervical ventral bronchus; (d) intraspecifically highly variable medial sequence of secondary airways; (e) sac-like laterobronchi; and, (f) grossly dead-ended caudal group bronchi in the caudal and ventral aspects of the lung. The primary differences between the two taxa are in the overall number of large bronchi (fewer in *P. palpebrosus*), and the number of branches that contribute to the cardiac regions. Imaging data of both a live and deceased specimen under varying states (postprandial, fasting, total lung capacity, open to atmosphere) indicate that the caudal margin and position of the lungs shift craniocaudally relative to the vertebral column. These imaging data suggest that the smooth thoracic ceiling may be correlated to visceral movement during ventilation, but this hypothesis warrants validation. These results provide the scaffolding for future comparisons between crocodilians, for generating preliminary reconstructions of the ancestral crocodilian bronchial tree, and establishing new hypotheses of bronchial homology across Archosauria.

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Dunlop, E., Shepherd, C.C.J., Cunningham, J., Strobel, N., Lucas, R.M. and Black, L.J. (2022). Vitamin D composition of Australian game products. *Food Chemistry* (doi: 10.1016/j.foodchem.2022.132965).

**Abstract:** The vitamin D content of many Australian game products is unknown. These foods are potential sources of vitamin D for remote-dwelling Aboriginal and Torres Strait Islander people, of whom 39% are vitamin D deficient (serum 25-hydroxyvitamin D<sub>3</sub> (25(OH)D<sub>3</sub>) concentrations <50 nmol/L). Vitamin D<sub>3</sub>, 25(OH)D<sub>3</sub>, vitamin D<sub>2</sub> and 25(OH)D<sub>2</sub> were measured by liquid chromatography-triple quadrupole mass spectrometry (LC-QQQ) in raw meat (camel, crocodile, emu, kangaroo), emu eggs and emu oil. Vitamin D<sub>3</sub> (range, 0.5-14.5  $\mu$ g/100 g) was found in all products except camel and kangaroo. All samples except kangaroo contained 25(OH)D<sub>3</sub>; some camel samples contained relatively high concentrations (range, 0.4-5.2  $\mu$ g/100 g). Vitamin D<sub>2</sub> was found in emu products and some kangaroo samples. We detected trace amounts of 25(OH)D<sub>2</sub> in some camel and kangaroo samples. This study provides valuable insight into foods with a paucity of data on vitamin D content, showing that some are potentially useful sources of vitamin D.

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Thiendedsakul, P., Santativongchai, P., Boonsoongnern, P., Yodsheewan, R. and Tulayakul, P. (2022). Glutathione-S-transferase activity in various organs of *Crocodylus siamensis* and its attenuation role in aflatoxin B1-induced cell apoptosis in human hepatocarcinoma cells. *Veterinary World* 15(1): 46-54.

**Abstract:** The crocodile is a model for studying relevant sources of environmental contamination. They were determined an appropriate biomonitoring species for various toxins. The cytosolic and microsomal fraction of crocodiles plays a role in detoxifying xenobiotics. Cytochrome P450 1A2 (CYP1A2) metabolizes aflatoxin B1 (AFB1) to aflatoxin M1, while glutathione-S-transferase (GST) catalyzes carcinogenic agents. This study aimed to investigate the GST activity in various organs of *Crocodylus siamensis*. Further, the fate of microsomal and cytosolic fractions from various crocodile organs against AFB1-induced apoptosis in human hepatocarcinoma (HepG2) cells was investigated. The liver, lungs, intestines, and kidneys tissues from a 3-year-old crocodile (*C. siamensis*) (n= 5) were collected. The cytosolic and microsomal fraction of all tissues

was extracted, and protein concentrations were measured with a spectrophotometer. Subsequently, a comparison of GST activity from various organs was carried out by spectrophotometry, and the protective effects of CYP450 and GST activity from various crocodile organs were studied. *In vitro* AFB1-induced apoptosis in HepG2 cells was detected by reverse transcription-quantitative polymerase chain reaction. Comparisons between the metabolisms of the detoxification enzyme in organs were tested using the Kruskal-Wallis one-way analysis of variance and Dunn's multiple comparison tests. All kinetic parameters were analyzed using GraphPad Prism software version 5.01 (GraphPad Software Inc., San Diego, USA). Total GST activity in the liver was significantly higher than in the kidneys, intestines, and lungs ( $p < 0.05$ , respectively). The highest GST pi (GSTP) activity was found in the liver, while the highest GST alpha-isoform activity was in the crocodile lung. The kinetics of total GST and GST mu activity in the liver had the highest velocity compared to other organs. In contrast, the kinetics of GSTP enzyme activity was the highest in the intestine. The *in vitro* study of microsome and cytosol extract against apoptosis induced by AFB1 revealed that the level of messenger RNA expression of the Bax and Bad genes of HepG2 cells decreased in the treatment group in a combination of cytosolic and microsomal fractions of the crocodile liver but not for Bcl-2. Interestingly, the downregulated expression of Bax and Bad genes was also found in the microsome and cytosol of crocodile kidneys. The crocodile liver revealed very effective GST activity and expression of the highest kinetic velocity compared to other organs. The combination of liver microsomal and cytosolic fractions could be used to prevent cell apoptosis induced by AFB1. However, further study of the molecular approaches to enzyme activity and apoptosis prevention mechanisms should be carried out.

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Beeching, S.C., Elsey, R.M. and Rehorek, S.J. (2022). Ontogeny of the American alligator (*Alligator mississippiensis*) prenatal head: A morphometric approach. *Journal of Morphology* (doi: [10.1002/jmor.21472](https://doi.org/10.1002/jmor.21472)).

**Abstract:** Variation in vertebrate cranial morphology is both extensive and functionally significant. Morphometric analysis attempts to explain such variation in form in evolutionary and functional contexts. Developmental morphometric analyses of vertebrate crania are less common, and many taxa are underrepresented. For example, the published morphometric studies of crocodilian cranial development focus mainly on posthatchling head development, with few, incomplete morphometric analyses of prehatchling heads. To further explore ontogenetic changes in the alligator head, we recorded and analyzed six linear cranial measurements in 77 preserved embryonic and hatchling American alligators (*Alligator mississippiensis*) representing 20 different stages. Examination of individual measurements revealed nonlinear changes in growth rate during development, suggesting a level of dynamic complexity worthy of further analysis. Using principal components analysis, we identified three distinct phases in prenatal alligator head growth. The second (intermediate) phase disrupts an otherwise monotonic developmental trajectory and represents a phase of reduced snout growth. Although this is a detailed description of prehatchling ontogenetic trajectory of the alligator head, further studies in other crocodilians are needed to assess evolutionary patterns among crocodilians.

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Hu, M.Y., Yu, J., Lin, J.Q. and Fang, S.G. (2022). Sex-biased miRNAs in the gonads of adult Chinese alligator (*Alligator sinensis*) and their potential roles in sex maintenance. *Frontiers in Genetics* (doi: [10.3389/fgene.2022.843884](https://doi.org/10.3389/fgene.2022.843884)).

**Abstract:** MicroRNA (miRNA) is a category of single-stranded non-coding small RNA (sRNA) that regulates gene expression by targeting mRNA. It plays a key role in the temperature-dependent sex determination of Chinese alligator (*Alligator sinensis*), a reptile whose sex is determined solely by the temperature during

the incubation period and remains stable thereafter. However, the potential function of miRNAs in the gonads of adult Chinese alligators is still unclear. Here, we prepared and sequenced sRNA libraries of adult female and male alligator gonads, from breeding (in summer) and hibernating (in winter) animals. We obtained 130 conserved miRNAs and 683 novel miRNAs, which were assessed for sex bias in summer and winter; a total of 65 miRNAs that maintained sex bias in both seasons were identified. A regulatory network of sex-biased miRNAs and genes was constructed. Sex-biased miRNAs targeted multiple genes in the meiosis pathway of adult Chinese alligator oocytes and the antagonistic gonadal function maintenance pathway, such as MOS, MYT1, DMRT1, and GDF9. Our study emphasizes the function of miRNA in the epigenetic mechanisms of sex maintenance in crocodilians.

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Queiroz, M.V.L. (2022). A new Peirosauridae (Crocodyliformes Notosuchia) from the Adamantina Formation (Bauru Group, Late Cretaceous), and a new phylogenetic analysis of notosuchians. MSc thesis, Universidade Estadual Paulista, São José do Rio Preto, Brazil.

**Abstract:** Peirosauridae is one of the fossil crocodyliform groups found in the Bauru Basin deposits. The fossil record of this group of Notosuchia spans across Gondwana, with important forms described for Brazil. In this work, we describe a new species of Peirosauridae that possesses a rostrum of platyrostral or nearly tubular proportions, found in the Adamantina Formation (Bauru Basin, Late Cretaceous). The specimen consists of a partially preserved skull with a cranial table, interorbital region and fragments of the posterior portion of the rostrum, including the prefrontal and lacrimal; left hemimandible, with 14 alveoli and 12 teeth; and a single cervical rib fragment. The specimen can be attributed to the Peirosauridae clade by the presence of a posteriorly closed optical opening in the form of a triangle, with a dorsally directed apex; the absence of elevated and hypertrophied supratemporal borders; for having a concave postorbital descending process lateral surface; and a dentary with lateral concavity to receive an enlarged maxillary tooth. The new specimen was assigned to a new taxon based on a series of autapomorphies that distinguish it from its immediate sister taxa, such as teeth with smooth canines; its posteroventral border of the quadratojugal that does not reach the square condyles; the distal edges of the square have only a posteriorly facing plane; and the paraoccipital process that, in the occipital view, presents a horizontal orientation. To clarify the position of the new Peirosauridae, as well as to elucidate the topology of the group with the inclusion of several possible members, a phylogenetic analysis was performed including data from three independent matrices with increased representation of Notosuchia, especially the Peirosauridae. Our results indicated the monophyly of Peirosauridae, formed by two main lineages of Peirosuchinae and Peirosaurinae, as previously proposed. Parallel to this result, we find the Argentinian *Colhuehuapisuchus lunai*, originally described as a Peirosauridae, nested within the Mahajangasuchidae, thus expanding the spatial distribution of the group as another Notosuchia clade widespread in Gondwana.

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Chudzik, P. and Iwaszczuk, U. (2022). "A crocodile spirit, crocodile-faced": Discovery of crocodile remains in the Early Middle Kingdom tombs of the North Asasif Necropolis in Western Thebes (Egypt). *Journal of African Archaeology* (<https://doi.org/10.1163/21915784-bja10016>).

**Abstract:** The recent discovery of Nile crocodile remains in the mortuary complexes of two high-ranking courtiers of Nebhepetra Mentuhotep II, located in the early Middle Kingdom necropolis in the valley of North Asasif, opened the way to an exploration of the role of reptile remains in funerary contexts. The skeletal remains, which were not mummified, consisted of fragments of the skull and mandible, loose teeth, and osteoderms. This paper explores the association that may have existed between the deceased and the crocodile god Sobek, whom the ancient Egyptians identified with pharaonic power, inundation and fertility. From the Middle

Kingdom, Sobek, who was believed to have risen from the Primeval Waters, was merged with the sun-god Ra, and in the solar form of Sobek-Ra was made part of the eternal journey of the sun from the east to the west. This association was also reflected in the Spells of the Coffin Texts, in which the deceased became Sobek.

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Velasco, A. and De Sola, R. (2022). Variations in the pattern of post occipital and nuchal scales in *Crocodylus intermedius* (Orinoco crocodile). *Boletín de la Academia de Ciencias Físicas, Matemáticas y Naturales LXXXII*(1): 19-23.

**Abstract:** One of the main characteristics of crocodile species is the patterns of the postoccipital and nuchal scales. These are different for every species, and only for *Crocodylus acutus*, a species with great variability have been studied in detail. To determine the pattern of the postoccipital and nuchal scales in the Orinoco crocodile (*Crocodylus intermedius*), 530 individuals were photographed and each photo was vectorized by drawing the pattern of the postoccipital and nuchal scales. Ten postoccipital scale patterns and 27 nuchal patterns were identified. The postoccipital pattern most frequently found (54.3%) consisted of four scales in a row, two on each side of the head. The most recurrent nuchal pattern (70.0%) entails two rows of large scales, the anterior one with four scales and the second one of only two (4-2). The rest of the patterns obtained were variations due to the presence of additional scales for each case. The combination of postoccipital and nuchal patterns is confirmed by definition 2-2 and 4-2, respectively. The study confirms the patterns defined by Brazaitis (1973) for the postoccipital and nuchal scales.

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Siregar, I. and Yahaya, S.R. (2022). Semiotic exploration of Roti Buaya as a cultural ornament. *British Journal of Applied Linguistics* 2(1): 6-13.

**Abstract:** Roti Buaya is one of the snacks in Betawi weddings. Roti Buaya has become an icon of Betawi traditional marriage, which contains a certain sacredness and is believed to exist by what has been passed down from generation to generation by the ancestors of the Betawi Tribe. The use of Roti Buaya was intended to remove the negative stigma attached to crocodiles. This research uses a semiological or semiotic research approach, which can also be termed qualitative research, which does not use calculations. This type of research is field research which is direct life research, which studies intensively about individuals or society. The author, in this case, focuses on the study of semiotics contained in Roti Buaya. This study examines the relationship, process, and meaning of Roti Buaya in marriage customs in Jagakarsa. The attitude of the Betawi people in the Jagakarsa region, which in modern times still preserves their customs, is very exemplary. The Betawi people in the Jagakarsa region are still loyal to using Roti Buaya. The Betawi people in the Jagakarsa area make the crocodile a symbol that must be present when the Betawi traditional wedding ceremony is held, as a symbolic form of the meanings of prayer, hope, and noble cultural values.

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Fukuda, Y., McDonald, P.J. and Crase, B. (2022). Lost to the sea: Predicted climate change threats to Saltwater crocodile nesting habitat. *Front. Ecol. Evol.* 10: 839423 (doi: [10.3389/fevo.2022.839423](https://doi.org/10.3389/fevo.2022.839423)).

**Abstract:** Climate change is predicted to have devastating impacts on apex predators such as eliminating their required habitats. Crocodylians are no exception as most species require freshwater for nesting, and such freshwater habitats are particularly vulnerable to saltwater inundation (SWI) caused by the sea level rise (SLR) from global warming. Here, we examined the impacts of climate change on saltwater crocodiles *Crocodylus porosus* in terms of the potential loss of nesting habitat in the Northern Territory, Australia; an area that contains the world's most extensive nesting habitat for the species. Our spatial model, derived from 730 nest

locations and selected environmental features, estimated a total of 32,306.91 km<sup>2</sup> of current suitable habitat across the study region. The most important variable was distance to perennial lakes (71.0% contribution, 87.5% permutation importance), which is negatively correlated with nesting habitat suitability. We found that projected changes in temperature and rainfall by 2100 could impact the area of suitable nesting habitat negatively or positively (0.33% decrease under low future emission climate scenario, and 32.30% increase under high emission scenario). Nevertheless, this can be canceled by the strong negative impact of SLR and concomitant SWI on nesting areas. A portion (16.40%) of the modeled suitable habitat for a subsection of our study area, the Kakadu Region, were already subject to >0.25 m SWI in 2013. The suitable area for nesting in this region is predicted to be further reduced to 1775.70 km<sup>2</sup> with 1.1 m SLR predicted for 2100, representing 49.81% loss between 2013 and 2100. Although the estimates of habitat loss do not account for the potential creation of new habitat, nor for the uncertainty in the degree of future SLR, our results suggest that SLR driven by continuing global warming can be the major threat to mound-nest-building crocodylians including *C. porosus*, rather than direct impacts from changes in temperature and rainfall. The degree of impact on saltwater crocodiles will be determined by the interplay between the loss of nesting habitat, which would appear inevitable under current global warming, and the ability to expand into new areas created by the expansion of the tropics.

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Larreal, J.T., Quintero-Torres, E. and Barros, T.R. (2022). Effects of depth in semi-controlled artificial incubation on egg hatching success of *Crocodylus acutus* (Cuvier, 1807) and hatchlings biometry. *Basic and Applied Herpetology* 37 (doi: <http://dx.doi.org/10.11160/bah.234>).

**Abstract:** Semi-controlled artificial incubation methods of crocodile eggs use low technology devices where one or more parameters cannot be controlled, but with the advantage that they are less expensive and logistically more feasible. This study evaluated the effect of different artificial incubation depths on the hatching success of eggs of *Crocodylus acutus*, under semi-controlled conditions, and analyzed biometric data of the hatchlings. The crocodile nests were collected from sandbanks of the two rivers (Río Negro and Río Santa Rosa), both located at Machiques de Perijá, Zulia state, Venezuela. The results showed a significant and positive effect on hatching success when the eggs were buried at 2 cm depth, compared to those at 10 cm and 20 cm. The hatching success at 2 cm depth was 82.43%. Also, we found that the size and weight of the hatchlings, as well as the relationships between these biometric variables, depend on the place of origin of the nests. The highest hatching percentage obtained at 2 cm was probably due to the effect of optimal incubation temperatures at this depth. The isolation and controlled heating system of the incubation room would prevent extreme fluctuations in temperature, favoring greater hatching at 2 cm depth. Differences in the biometric aspects of the hatchlings could be associated with differences in the size and the physiological status of the females from both sites.

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Portelinha, T.C.G., Verdade, L.M. and Piña, C.I. (2022). Detectability of *Caiman latirostris* (Crocodylia: Alligatoridae) in night count surveys. *South American Journal of Herpetology* 23(2): 25-31.

**Abstract:** Night count surveys are one of the most used methods to study distribution and population parameters in crocodylians. However, there are some methodological constraints that prevent the visualization of animals submerged or hidden behind vegetation. We studied the proportion of caimans that were detectable to observers during night count surveys based on the monitoring of 7 adult *Caiman latirostris* females with radio transmitters (VHF, GPS and UHF). Fieldwork was carried out in a protected area with a natural stream and a lagoon (30°11'26"S, 61°00'27"W) between 12 January and 29 April 2011 in Santa Fe, Argentina. Only locations acquired at night (18:00-05:00) were considered for analysis, and those acquired

within vegetation were considered potentially undetectable. As the lagoon is mostly covered with vegetation (eg cattail), most of the animals were not visible to observers (62.5-100%, average >80%). In contrast, virtually all individuals (100%) were potentially visible in the stream. The use of data collected in telemetry studies can be useful to estimate detectability of cryptic species such as the broad-snouted caiman. An understanding of animal detectability is necessary, as counts of individuals is often used in decision-making for crocodylian conservation, sustainable use, and control.

Parunyakul, K., Srisuksai, K., Santativongchai, P., Pongchairerk, U., Ampawong, S., Tulayakul, P. and Fungfuang, W. (2022). The first study on the effect of crocodile oil from *Crocodylus siamensis* on hepatic mitochondrial function for energy homeostasis in rats. *Veterinary World* 15(4): 986-997.

**Abstract:** Consumption of fatty acids (FA) can alter hepatic energy metabolism and mitochondrial function in the liver. Crocodile oil (CO) is rich in mono- and polyunsaturated FAs, which have natural anti-inflammatory and healing properties. In rat livers, we investigated the effect of CO on mitochondrial function for energy homeostasis. Twenty-one male Sprague-Dawley rats were divided into three groups at random. Group 1 rats were given sterile water (RO), Group 2 rats were given CO (3% v/w), and Group 3 rats were given palm oil (PO) (3% v/w). For 7 weeks, rats were given sterile water, CO, and PO orally. The researchers looked at body weight, food intake, liver weight, energy intake, blood lipid profiles, and mitochondria-targeted metabolites in the liver. The liver's histopathology, mitochondrial architecture, and hydrolase domain containing 3 (HDHD3) protein expression in liver mitochondria were studied. Body weight, liver weight, liver index, dietary energy intake, and serum lipid profiles were all unaffected by CO treatment. The CO group consumed significantly less food than the RO group. The CO group also had significantly higher levels of oxaloacetate and malate than the PO group. CO treatment significantly ameliorated hepatic steatosis, as evidenced by a greater decrease in the total surface area of lipid particles than PO treatment. CO administration preserved mitochondrial morphology in the liver by upregulating the energetic maintenance protein HDHD3. Furthermore, chemical-protein interactions revealed that HDHD3 was linked to the energy homeostatic pathway. CO may benefit liver function by preserving hepatic mitochondrial architecture and increasing energy metabolic activity.

Lee, H., Kim, E., Kim, H., Jung, J.Y., Kim, M.I. and Moon, S. (2022). Species identification from suspected crocodile leather products using mitochondrial 12S ribosomal RNA and cytochrome b genes. *Journal of Forensic Science* 16(1): 47-55.

**Abstract:** In the field of forensic science, species identification plays an important role for strong regulation of illegal wildlife trade. In 2020, the Gyeongsangnam-do Provincial Police Agency requested a species analysis of five types of crocodile leather products that were evidence of smuggling. For this purpose, species identification was performed through sequencing of the PCR products for mitochondrial 12S ribosomal RNA and cytochrome b gene. PCR products could not be obtained from the outer part of the bones, claws, and teeth located inside the leather or leather, but normal PCR products could be obtained from the inside of the skull, the presumed blood vessels inside the jaw, and the inner parts of the bones, claws, and teeth. As a result of BLAST analysis of the nucleotide sequences of the PCR products of the two genes, it was 100% identical to the species '*Crocodylus siamensis* (Siamese crocodile)'. In addition, the results of neighbor-joining phylogenetic tree analysis using the sample sequence together with the sequence of other crocodiles obtained from NCBI showed that it was 100% identical to that of '*Crocodylus siamensis*'. Although mitochondrial DNA is useful for species identification in the forensic field, this case demonstrates the potential for mitochondrial DNA in leather products to be damaged during leather processing. Therefore, it will

be necessary to find a site where DNA is not damaged as much as possible during the leather processing process.

Vashistha, G., Ranjan, V., Ansari, A.G. and Dhakate, P.M. (2022). Evidence of gharial, *Gavialis gangeticus* (Crocodylia: Gavialidae), nesting in the Ramganga River, Corbett Tiger Reserve, India. *Herpetology Notes* 15: 179-182.

Nie, H., Wen, Y., Zhang, R., Wu, M., Zhang, Y., Xu, Y., Zhan, J. and Wu, X. (2022). The histological and ultrastructure morphology, global analysis of differential gene expression through transcriptome sequencing related to seasonal sperm storage in oviduct of female Chinese alligator, *Alligator sinensis*. *Reproduction, Fertility and Development* (<https://www.publish.csiro.au/RD/justaccepted/RD21191>).

**Abstract:** Although oviductal sperm storage are essential steps in reproduction for female animals with internal fertilization, no systematic study on the identification of genes involving sperm storage has been performed in crocodylian species. In the present research, the relationship between morphological variation related to sperm storage in the oviduct and gene expression patterns derived from RNA sequencing analyses between active period (AP), breeding period (BP), and hibernation period (HP) were investigated. The corresponding results indicated that sperm were observed not only in the ciliated cells within infundibulum and mucosal layer of uterus during BP, but also been detected in the spermatosome storage tube (SST) in the anterior uterus at HP stage. The further transmission electron microscopy analysis indicated that the differences in the number and activity of the secretory cells likely to attributed to the seasonal variation of microenvironment related to the sperm storage. Based on the RNA-sequencing, 13147 DEGs related to the Peroxisome proliferator-activated receptors (PPARs) and FOXO signaling were identified, including these, the down-regulated ATG12 and BCL2L11 in HP group may thus constitute an important point of convergence between autophagy and apoptosis involving in FOXO1 pathway. The genes involving in PPARs pathway might modulate the immune response and thereby contribute to prolong the life span of stored spermatozoa in *A. sinensis*. The outcomes of this study provide fundamental insights into the mechanism of sperm storage in *A. sinensis*.

Rummy, P. and Rummy, J. (2022). Boon or bane? The significance of scientific knowledge and education consciousness for crocodylian conservation in Malaysia. *ASM Sc. J.* 17 (<https://doi.org/10.32802/asmsej.2022.1014>).

**Abstract:** A fundamental scientific apprehension of the exact nature of crocodiles, combined with the awareness through education for these reptiles could provide a crucial opportunity to enhance the conservation efforts in Malaysia. In this review article, we emphasised that there is a necessity to safeguard estuarine crocodiles (*Crocodylus porosus*) and the Malayan gharials (*Tomistoma schlegelii*) in the local ecosystem. More so, we aim to propose sustainable protection standards for these reptiles. We reviewed selected scientific studies related to crocodylians, and resources with regard to local environmental education and overall wildlife conservation efforts. We deem that the exposure to crocodylian scientific knowledge is exceptionally rare in Malaysia as compared to other wildlife. We argue that the erosion of knowledge will have adverse impacts in safeguarding the species. The discussion further highlighted the need to redress existing biodiversity policies and foregrounding formal biodiversity curriculum and literacy for constructive nature ownership in Malaysian schools.

Hekkala, E.R., Colten, R., Cunningham, S.W., Smith, O. and Ikram, S. (2022). Using mitogenomes to explore the social and ecological contexts of crocodile mummification in ancient Egypt. *Bulletin of*

the Peabody Museum of Natural History 63(1): 3-14.

**Abstract:** We used isotopic and genomic data to explore the ecological and social context of cultural practices associated with the mummification of crocodiles in ancient Egypt. Ancient DNA was recovered from four mummified crocodile hatchlings held in the collections of the Peabody Museum of Natural History, Yale University. Previous genetic analyses of crocodile mummies have indicated that most mummies represent the newly resurrected taxon, *Crocodylus suchus* Geoffroy Saint-Hilaire, 1807. However, mitogenomic data for the Yale Peabody Museum mummies indicates that these specimens represent the first genomically authenticated representatives of the Nile crocodile (*Crocodylus niloticus* Laurenti, 1768) in museum collections. We explore these findings within the broader context of modern and historical distributions of both crocodile species and the potential implications for our understanding of funerary practices involving crocodiles in ancient Egypt.

Campbell, M.A., Udyawer, V., Jardine, T.D., Fukuda, Y., Kopf, R.K., Bunn, S.E. and Campbell, H.A. (2022). Dietary shifts may underpin the recovery of a large carnivore population. *Biology Letters* 18: 20210676.

**Abstract:** Supporting the recovery of large carnivores is a popular yet challenging endeavour. Estuarine crocodiles in Australia are a large carnivore conservation success story, with the population having extensively recovered from past heavy exploitation. Here, we explored if dietary changes had accompanied this large population recovery by comparing the isotopes  $\delta^{13}\text{C}$  and  $\delta^{15}\text{N}$  in bones of crocodiles sampled 40 to 55 years ago (small population) with bones from contemporary individuals (large population). We found that  $\delta^{13}\text{C}$  and  $\delta^{15}\text{N}$  values were significantly lower in contemporary crocodiles than in the historical cohort, inferring a shift in prey preference away from marine and into terrestrial food webs. We propose that an increase in intraspecific competition within the recovering crocodile population, alongside an increased abundance of feral ungulates occupying the floodplains, may have resulted in the crocodile population shifting to feed predominantly upon terrestrial food sources. The number of feral pigs consumed to sustain and grow crocodile biomass may help suppress pig population growth and increase the flow of terrestrially derived nutrients into aquatic ecosystems. The study highlights the significance of prey availability in contributing to large carnivore population recovery.

Cox, N., Young, B.E., Bowles, P., Fernandez, M., Marin, J., Rapacciuolo, G., Böhm, M., Brooks, T.M., Hedges, S.B., Hilton-Taylor, C., Hoffmann, M., Jenkins, R.K.B., Tognelli, M.F., Alexander, G.J., Allison, A., Ananjeva, N.B., Auliya, M., Avila, L.J., Chapple, D.G., Cisneros-Heredia, D.F., Cogger, H.G., Colli, G.R., de Silva, A., Eisemberg, C.C., Els, J., Fong G., A., Grant, T.D., Hitchmough, R.A., Iskandar, D.T., Kidera, N., Martins, M., Meiri, S., Mitchell, N.J., Molur, S., de C Nogueira, C., Ortiz, J.C., Penner, J., Rhodin, A.G.J., Rivas, G.A., Rödel, M-O., Roll, U., Sanders, K.L., Santos-Barrera, G., Shea, G.M., Spawls, S., Stuart, B.L., Tolley, K.A., Trape, J-F., Vidal, M.A., Wagner, P., Wallace, B.P. and Xie, Y. (2022). A global reptile assessment highlights shared conservation needs of tetrapods. *Nature* (doi: 10.1038/s41586-022-04664-7).

**Abstract:** Comprehensive assessments of species' extinction risks have documented the extinction crisis and underpinned strategies for reducing those risks. Global assessments reveal that, among tetrapods, 40.7% of amphibians, 25.4% of mammals and 13.6% of birds are threatened with extinction<sup>3</sup>. Because global assessments have been lacking, reptiles have been omitted from conservation-prioritization analyses that encompass other tetrapods. Reptiles are unusually diverse in arid regions, suggesting that they may have different conservation needs. Here we provide a comprehensive extinction-risk assessment of reptiles and show that at least 1829 out of 10,196 species (21.1%) are threatened-confirming a previous

extrapolation and representing 15.6 billion years of phylogenetic diversity. Reptiles are threatened by the same major factors that threaten other tetrapods-agriculture, logging, urban development and invasive species-although the threat posed by climate change remains uncertain. Reptiles inhabiting forests, where these threats are strongest, are more threatened than those in arid habitats, contrary to our prediction. Birds, mammals and amphibians are unexpectedly good surrogates for the conservation of reptiles, although threatened reptiles with the smallest ranges tend to be isolated from other threatened tetrapods. Although some reptiles-including most species of crocodiles and turtles-require urgent, targeted action to prevent extinctions, efforts to protect other tetrapods, such as habitat preservation and control of trade and invasive species, will probably also benefit many reptiles.

Offor, I. (2022). Global animal law and the problem of "Globabble": Toward decoloniality and diversity in global animal law studies. *Asian Journal of International Law* 2022: 1-30.

**Abstract:** Global animal law has emerged as a new legal subdiscipline and area of study following the widespread proliferation of animal law and animal law studies across the globe. However, there remains confusion as to what exactly global animal law is. Early global animal law studies are also entrenching norms that facilitate coloniality and neglect intersecting oppressions. In response, this article proposes a conception of global animal law based in global law metatheory and second wave animal ethics. This article critically analyses instances of "globabble" within global animal law, where global-speak has masked ethnocentric, western influence, and bias. This article recommends diversifying and decolonizing global animal law, relabelling some such work as western/European perspectives on animals and international law. It also recommends focusing on deep, critical, and radical animal justice in lieu of welfarism or rights-based theory. The article argues this could inspire a more interconnected, post-Westphalian, multilateral global animal lawscape.

Finger Jr., J.W., Kelley, M.D., Zhang, Y., Ka, C., Hamilton, M.T., Elsey, R.M., Kavazis, A. and Mendonca, M.T. (2022). Relationships of brain glucocorticoid receptors and commonly used stress parameters with body condition of juvenile American alligators (*Alligator mississippiensis*). *South American Journal of Herpetology* 23: 42-48.

**Abstract:** Crocodylians in aquacultural settings exhibit variations in growth and condition. The underlying cause of this has yet to be elucidated, but corticosterone (CORT, the main crocodylian stress hormone) is thought to play a role in this. In this study, we measured baseline plasma CORT, heterophilymphocyte (H/L) ratios, relative glucocorticoid receptor (GR) levels in the forebrain, and body condition index (BCI) of juvenile American alligators (*Alligator mississippiensis*). Both univariate and multivariate analyses were used to investigate underlying relationships. In univariate analysis, BCI was negatively related with GR levels, but not by plasma CORT. Multivariate analysis revealed that both relative forebrain GR levels and plasma CORT were negatively related with alligator BCI: alligators with higher body condition had lower levels of CORT and GRs. However, H/L ratios were unrelated to BCI. Our results implicate dysregulation of the hypothalamic-pituitary-adrenal axis as an important factor influencing crocodylian body condition.

Barrow Jr., M.V. and Woodward, A.R. (2022). Acting in the face of uncertainty: The campaign to save the American alligator. *Environmental History* 27(2): 328-333.

Funes Monzote, R. and Pérez Fleitas, E.A. (2022). In grave danger: A brief environmental history of the Cuban crocodile (*Crocodylus rhombifer*). *Environmental History* 27(2): 320-327.

Vergara, G. and Wakild, E. (2022). Extinction and its interventions in the Americas. *Environmental History* 27(2): 294-307.

**Abstract:** This forum argues that environmental historians ought to pay more attention to animal extinction - the disappearance of a lineage of life - than they have to date. Examining the pre-and post-extinction contexts of charismatic terrestrial vertebrates in the Americas certainly underscores the power humans have had over other animals and their habitats. Yet, the contingencies and unexpected results of conservation efforts merit no less attention. Indeed, by uncovering important nuances in the extension of human power, they provide insights into the conditions critical to avoid extinction. As environmental history has long shown, abstracting the human from the nonhuman world distorts the history of both. Thus, leaving extinction to other disciplines misrepresents what historians can offer and how societies can address ongoing crises of extinction. In this forum, historians partner with scientists in collaboratively composed essays, negotiated across stylistic conventions and subject orientations, to highlight the latent promise of such partnerships. In doing so, they engage spatial and temporal scales that clearly illustrate the significance of deep history and historicize extinction by calling attention to the power, production, and scales of species decline.

Marioni, B., Magnusson, W.E., Vogt, R.C. and Villamarín, F. (2022). Home range and movement patterns of male dwarf caimans (*Paleosuchus palpebrosus* and *Paleosuchus trigonatus*) living in sympatry in Amazonian floodplain streams. *Neotropical Biodiversity* 8(1): 156-166.

**Abstract:** Dwarf caimans (Alligatoridae: *Paleosuchus palpebrosus* and *Paleosuchus trigonatus*), are small crocodylians exhibiting cryptic behaviour and complex habitat use that occur throughout the Amazon region. Our goals were to evaluate individual home range, habitat occupancy and movement patterns where they occur in sympatry in relation to seasonal water-level variation. We tracked 5 *P. palpebrosus* and 7 *P. trigonatus* using VHS radio transmitters along the shores of two streams directly influenced by the flooding pulse of the Purus River. *Paleosuchus palpebrosus* individuals moved greater distances on a daily basis and had larger home ranges than *P. trigonatus*, and the species had different responses to increases in water levels. *Paleosuchus palpebrosus* moved into flooded forests, as do their principle prey species. Conversely, larger *P. trigonatus* individuals usually remained near the main stream, and were relatively sedentary. Intraspecific home-range overlap was higher than interspecific overlap in both species. Thus, habitat occupancy patterns as a function of water-level variation might facilitate coexistence of the two species of dwarf caimans in the same location. This study shows that when living in sympatry under a seasonal flooding regime, *Paleosuchus* species show a degree of habitat partitioning evidenced by different daily movement rates, homerange sizes and home-range locations.

Paiman, A., Albayudi, A. and Habibullah, H. (2022). Density of false gharial (*Tomistoma schlegelii*) in the Air Hitam Laut River, TNB. (<https://repository.unja.ac.id/32785>).

**Abstract:** Indonesia is a country that has high diversity. There are four types of crocodiles that are protected in Indonesia, one of which is the false gharial (*Tomistoma schlegelii*). Jambi province is a good place for the life of the false gharial. However, currently the population in nature is under serious threat and the number of individuals is decreasing. Over the past three decades, the Sinyulong crocodile population has shrunk by 30% due to habitat fragmentation (Bezuijen *et al.* 2014) and hunting has made this crocodile threatened so that this species has decreased in population and only survives in a few isolated rivers, especially in Sumatra and Kalimantan (Auliya *et al.* 2006; Stuebing *et al.* 2006), Sarawak and Peninsular (Bezuijen *et al.* 2004). From 2016 to 2020 there has been no research on the density of the false gharial in the Berbak National Park area. The

purpose of this study was to calculate the density value of the false gharial in the Air Hitam Laut River. This research was conducted in Berbak National Park on the Air Hitam Laut River. The starting point of this research is 104°24'15"E, 1°21'29"S and the end point of this research is Air Hitam Laut River 104°20'45"E, 1°25'39"S. This research was carried out from July to November 2020. Data collection used the spotlight survey method. The best observation time is when the water recedes or the water level is low, observations are made from the downstream to the upstream part (Fukuda *et al.* 2013a). Observations were carried out at 18.30 WIB to 20.30 WIB, the observations were repeated three times on different days. Based on the research that has been done, it was found that two individuals of false gharials were at the age of children. So the result is that the density of the Sinyulong crocodile in the Air Hitam Laut River in 2020 is 0.04 individuals per kilometre. The density status of the Sinyulong crocodile in 2020 also decreased compared to the previous study in 2015 which was 0.13 individuals per kilometre decreased to 0.04 individuals per kilometre.

Siddiqui, R., Muhammad, J.S., Maciver, S.K. and Khan, N.A. (2022). *Crocodylus porosus* sera a potential source to identify novel epigenetic targets: *In silico* analysis. *Veterinary Sciences* 9: 210.

**Abstract:** We have previously found that sera from *Crocodylus porosus* contain anticancer agents and the treatment of MCF7 cells with this serum resulted in the differential expression of 51 genes. The purpose of this study was to use *in silico* analysis to identify genes that might be epigenetically modulated in cells treated with crocodile serum and to understand the role of potential genes as novel candidates with epigenetic therapeutic potential. The findings report five proto-oncogenes (TUBA1B, SLC2A1, PGK1, CCND1, and NCAPD2) and two tumor suppressor genes (RPLP2, RPL37) as novel therapeutic targets. Furthermore, we present a comprehensive overview of relevant studies on epigenetic regulation of these genes along with an insight into their clinical implications. Therefore, elucidating the molecules present in the serum and gut bacteria of reptiles such as crocodiles may offer insights into the role of these genes on longevity, health, disease, and life expectancy.

Pereira, A.C., Portelinha, T.C.G. and Malvasio, A. (2022). Population ecology and human disturbance effects on two caiman species in the southern Brazilian Amazon. *South American Journal of Herpetology* 23(1): 32-41.

**Abstract:** Although caiman populations are being conserved in some protected areas, they face threats related to human pressure, which may ultimately influence their distribution, abundance, and behavior. In this study, we investigated the population ecology (encounter rate, size structure, sex ratio, and injury frequency) and the effects of human disturbance on *Melanosuchus niger* and *Caiman crocodilus* populations in Cantão State Park, southern Brazilian Amazon, Central Brazil. We assessed human pressure on both populations, testing the human disturbance–abundance and human disturbance–size structure relationships. We sampled waterbodies within (lakes) and adjacent to (river) protected areas via nocturnal surveys and captures. Human pressure in the river was assessed and categorized via transects with low, medium, and high levels of disturbance. Our results indicate that *C. crocodilus* was more abundant than *M. niger*, with populations of both species mainly composed of juvenile males. We also observed that injuries were more prevalent in juveniles and males. Human disturbance negatively affected *C. crocodilus* abundance, but no effect was found for *M. niger*. We found no significant effect of human disturbance on size structure for either species; however, the response for each species differed. Snout-vent length (SVL) decreased with increasing human pressure level in the *C. crocodilus* population, whereas *M. niger* showed a greater SVL at higher human pressure levels. Our results suggest that human disturbance related to boat traffic, pollution, riverine population, land use, and human activities negatively influence crocodylian populations in their distribution through a distance-

abundance relationship. Additionally, the proximity of settlements and accessibility to protected areas are factors related to human disturbance and should be considered in government decisions and the management of protected areas by environmental agencies. Our results improve our understanding caiman population responses to human disturbance.

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Lemaire, J. (2021). Mercury Contamination in Caimans from French Guiana, Bioaccumulation and Physiological Effects. PhD thesis, La Rochelle University, La Rochelle, France.

**Abstract:** Mercury (Hg) is a global environmental contaminant that affects ecosystems. It has the particularity to biomagnify through the food web, and to bioaccumulate especially in tissues of top predators. Mercury has been identified to have detrimental effects on human and wildlife. Top predators from tropical ecosystems are particularly affected by Hg contamination due to artisanal small scale gold mining, which uses massive amounts of Hg in the gold extraction process. Crocodylians are top predators of tropical ecosystems and have been identified to accumulate high concentrations of Hg in their tissues. They are potentially good candidates to monitor Hg contamination, as they are long-living animals with low metabolic, and high tissue conversion rates, which favours the bioaccumulation of Hg. Additionally, they have a large repartition over tropical and sub-tropical ecosystems, which make large-scale Hg evaluation possible. My doctoral work focuses on the four caiman species that are present in French Guiana (the Black caiman *Melanosuchus niger*, the Dwarf caiman *Paleosuchus palpebrosus*, the Smoothfronted caiman *Paleosuchus trigonatus* and the Spectacled caiman *Caiman crocodilus*). First, I have worked on Hg variation across different tissues obtained by minimally invasive methods, and investigated the influence of morphology and feeding ecology (by using stable isotope method) on Hg contamination in caimans. Second, I have investigated the impact of Hg contamination on physiological mechanisms, and the maternal transfer and its effects on neonates. The quantification of Hg in blood and keratinized tissues of caimans is more reliable when using dry weight due to the variation of moisture content in different tissues. These tissues further inform on different time scales of Hg contamination: Relatively recent contamination in blood, and long-term contamination in keratinized tissues. Trophic ecology had been the main factor that influence Hg concentration; Body size of caimans was essential to be consider during Hg contamination assessment due to the bioaccumulation, and because caimans growth continuously. Results showed that Hg contamination was related to disruption of renal, hepatic and endocrine functions in young *C. crocodilus* at low Hg level, leading to potential toxic effects of Hg on caimans. Maternal transfer was evaluated in claws of freshly hatched *P. trigonatus*, which provides an effective method to quantify foetal Hg exposure, and additionally offers an alternative to evaluate maternal transfer in caimans, compared to egg destruction. In neonates, Hg exposure was related to a reduction of body size, which indicated a potential disruption during embryonic development. This doctoral work highlights that caimans are effective species to monitor Hg contamination, and stresses the need to thoroughly investigate the consequences of Hg contamination in crocodylians.

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Masi, M., Selleri, P. and Moore, B.A. (2022). Introduction to ophthalmology of Reptilia. Pp. 145-152 in Wild and Exotic Animal Ophthalmology, Volume 1, ed. by F. Montiani-Ferreira, B.A. Moore and G. Ben-Shlomo. Springer Nature: Switzerland.

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Martinez, P.S. and Plummer, C.E. (2022). Ophthalmology of crocodylians: alligators, crocodiles, caimans and gharials. Pp. 399-320 in Wild and Exotic Animal Ophthalmology, Volume 1, ed. by F. Montiani-Ferreira, B.A. Moore and G. Ben-Shlomo. Springer Nature: Switzerland.

Zimmerman, L.M. (2022). Adaptive immunity in reptiles: Conventional components but unconventional strategies. Integrative and Comparative Biology (<https://doi.org/10.1093/icb/icac022>).

**Abstract:** Recent studies have established that the innate immune system of reptiles is broad and robust, but the question remains: What role does the reptilian adaptive immune system play? Conventionally, adaptive immunity is described as involving T and B lymphocytes that display variable receptors, is highly specific, improves over the course of the response, and produces a memory response. While reptiles do have B and T lymphocytes that utilize variable receptors, their adaptive response is relatively nonspecific, generates a prolonged antibody response, and does not produce a typical memory response. This alternative adaptive strategy may allow reptiles to produce a broad adaptive response that complements a strong innate system. Further studies into reptile adaptive immunity cannot only clarify outstanding questions on the reptilian immune system but can shed light on a number of important immunological concepts, including the evolution of the immune system and adaptive immune responses that take place outside of germinal centers.

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Dong, J.S. and Meng, E. (2022). Antimicrobial resistance profiling of alligator gut microbiome isolates. Poster Presentation (Research Day, 30 April), Pacific Undergraduate Research and Creativity Conference, University of the Pacific, Stockton, California, USA.

**Abstract:** Antibiotic resistance research has become urgent due to the lack of development of new antibiotics and the increase in multi-drug resistant bacterial infections, which have become a global threat. Due to its large and diverse microbial population, the gut microbiome has been suggested to be a great candidate for antibiotic resistance research. In a recent study, antibiotic resistance gene elements were identified in samples of the gut of an American alligator. The goal of this project is to confirm antibiotic resistance among potential antibiotic-resistant isolated colonies from these previously mentioned alligator gut samples. Bacteria were isolated from this gut microbiota based on the resistance genes identified using a disk diffusion enrichment approach. The isolates were identified based on their 16S rRNA gene sequences, and we have tested some of these isolated strains for antibiotic resistance using a minimal inhibitory concentration (MIC) assay. The MIC assay was performed to determine antibiotic resistance within these selected strains against antibiotics, Ampicillin, Gentamycin, Tetracycline, Rifampin, Chloramphenicol, Kanamycin, and Ciprofloxacin, which are from different classes with different potencies. We found that six of the strains were multi-drug resistant. We found that Ciprofloxacin was mainly inhibitory to all the tested strains, while Ampicillin and Kanamycin were unable to inhibit any of the strains. Moving forward with this project we hope to successfully link the previously identified antibiotic resistance gene elements to resistance seen within the minimal inhibitory assay. This can deepen our understanding of the gut microbiome serving as a potential reservoir of antibiotic resistance elements which can aid in furthering the development of novel antibiotics.

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Bryant, S.R.D., Nunnally, C., Hanks, G. and McClain, C.R. (2022). The macrofaunal metropolis in the sediments around the first-ever deep-sea alligator fall. Marine Ecology (<https://doi.org/10.1111/maec.12707>).

**Abstract:** The maintenance of high diversity in deep-sea sediments is often hypothesized to be a result of heterogeneity in disturbance and carbon availability creating long-lived patches of unique communities. Deep-sea food falls are known to contribute to this patchiness, influencing the beta-diversity of soft-bottom communities through varying effects of enrichment and disturbance. Previous food fall work has centered on large (>1000 kg, eg whales) or small (0-10 kg, eg kelp, fish, wood) food parcels, leading to the hypothesis that only the largest persist long enough to impact

sediment communities. The effect of intermediately sized (10-1000 kg) carcasses on sediment macrofauna communities remains poorly understood. Here, we deployed an individual *Alligator mississippiensis* carcass (19.5 kg) as organic enrichment to an otherwise food-poor landscape at 2034 m in the northern Gulf of Mexico. Sediment cores collected at three distances from the alligator fall following decomposition were used to describe changes in macrofauna abundance and alpha- and beta-diversity. We found that the carcass enriched nearby sediments with up to three times more carbon than background sediments. This carbon enrichment near the carcass did not influence species richness but did correlate with higher abundance and a suite of species unique from background communities. Our findings suggest that the food fall size threshold above which enrichment of local sediments occurs may be lower than previously thought, as we demonstrate that an intermediately sized (19.5 kg) food fall can contribute carbon and promote beta- and thus gamma-diversity of the infaunal benthos.

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Reigh, R.C. and Williams, M.B. (2022). Growth effects of lysine in compounded diets for American alligator, *Alligator mississippiensis*. Journal of the World Aquaculture Association 2022: 1-11.

**Abstract:** Nutritional requirements of the American alligator, *Alligator mississippiensis*, are largely unknown despite the value of farm-raised alligator as an aquaculture product. We conducted a 10-month growth trial to determine effects of graded levels of dietary lysine on alligator growth as measured by increase in body length, body weight gain, and free lysine concentration in blood plasma. One-hundred-ninety-two hatchling alligators were fed 50% crude protein, pelletized diets, composed primarily of practical feed ingredients, with 1.5, 2.25, 3.0 or 3.75% dietary lysine. Diets were fed for 326 days under temperature-controlled, laboratory conditions. Body lengths and body weights were measured at 60-day intervals, and blood samples were taken at the final weighing. Increases in body length, body weight gain, and free lysine level in blood plasma indicated that a concentration of at least 2.25% dietary lysine (as fed) - about 4.5% of protein - was adequate for growth of alligator under the conditions of this study. Results suggest that the lysine requirement of American alligator is similar to requirements reported for other aquaculture species, including some fishes, crustaceans, and amphibians.

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Khoury Rebello, F., Trindade Gonçalves, P.C., Souza dos Santos M.A., Santana Bezerra, A., Cabral Soares, B. and Bahia Lopes, M.L. (2022). Segmentation of the wild animal meat consumer market in Belém Municipality, Pará State, Brazilian Amazon. Journal of Agricultural Studies 10(1): 127-144.

**Abstract:** The growing demand for nutritious protein-rich foods has increased the visibility of the wild animal meat market, and created an alternative replacement for traditional meats. The informality in this product offer is a characteristic feature of this market. It is necessary to certify the existence of a public in this market niche. This segmentation of the wild animal meat consumer market in Belém municipality, Pará state, in the Brazilian Amazon, was carried out to identify consumers' perceptions of the economic potential of this activity. Data were obtained from a representative sample of consumers in Belém, one of the most representative consumption centers in the Amazon. Market segmentation was performed using two multivariate techniques: factor analysis to simplify the original data matrix, and cluster analysis to identify homogeneous groups according to the highest degree of similarity of objects in relation to the attributes of interest. The survey results showed that factors such as consumption preferences, product availability, education level, income, and family composition are determinants of the consumption of wild animal meat. The study also confirmed the existence of a market for this product in food establishments such as bars and restaurants. The main wild animal meats consumed were tartaruga-da-Amazônia (*Podocnemis expansa*) (61.67%), alligator (*Alligatoridae*) (56.67%), paca (*Cuniculus paca*) (52.50%), deer

(Cervidae) (40.83%), armadillo (*Dasypodidae*) (40.00 %), muçunã (*Kinosternon scorpioides*) (30.83%), capybara (*Hydrochoerus hydrochaeris*) (29.58%), tortoise (*Chelonoidis*) (21.25%), tracajá (*Podocnemis unifilis*) (19.58%), peccary (*Pecari tajacu*) (17.08%) and sloth (*Folivora*) (12.92%). The expansion of this market, requires strategies to strengthen the regular sustainable supply of the product, including public initiative efforts regarding the regulatory framework of the activity and entrepreneurial efforts for the necessary investments in breeding and slaughtering system officers.

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Belcher, S.M., Guillette, M.P., Robb, F. and Rock, K.D. (2022). Comparative assessment of blood mercury in American alligators (*Alligator mississippiensis*) from coastal North Carolina and Florida. Preprint (<https://doi.org/10.21203/rs.3.rs-1495035/v1>).

**Abstract:** Mercury (Hg) is a widespread and potential harmful persistent contaminant of aquatic ecosystems. Except for the northern most populations of American alligators (*Alligator mississippiensis*) found in North Carolina, the potential adverse health impacts of Hg on ecosystems and humans consuming alligator meat has been studied for over three decades. Now that alligators are being recreationally hunted and consumed across their range, it is especially important to monitor toxic contaminant levels to best understand possible adverse impacts of exposures on alligator populations and human health. In this study we evaluated blood Hg levels in American alligators from an urbanized site in Wilmington, NC, a nearby site at Lake Waccamaw, NC, and a site on the St Johns River in Florida. Median blood total Hg concentrations were particularly high at Lake Waccamaw (526 ng/g, range 152-946 ng/g), resulting in median muscle concentrations (0.48 ppm, range 0.13-0.88 ppm) above the US EPA/FDA fish consumption advisory level of 0.3 ppm. Median concentrations at the Wilmington site (69 ng/g, range 22-336 ng/g) were low, and Hg concentrations from the St Johns River site (143 ng/g, range 54-244 ng/g) were comparable to those reported in previous studies. Analysis of relationships between total Hg concentrations and a panel of blood chemistry biomarkers found only modest concentration dependent impact on biomarkers of renal function. The results of this study reveal that local environmental factors greatly impact Hg bioaccumulation in alligators, findings that reaffirm that local contaminant biomonitoring in alligator populations will be critical for effective management and determination of guidelines for safe consumption of harvested alligators.

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Carossino, M., Nevarez, J.G., Sakaguchi, K., Paulsen, D.B., Langohr, I.M., Strother, K., Ferracone, J., Roy, A., Crossland, N.A. and Del Piero, F. (2022). An outbreak of systemic chlamydia in farmed American alligators (*Alligator mississippiensis*). Veterinary Pathology (doi: [10.1177/03009858221095269](https://doi.org/10.1177/03009858221095269)).

**Abstract:** *Chlamydia* spp are reported to cause systemic disease in a variety of hosts worldwide including few reports in crocodylians. Disease presentations vary from asymptomatic to fulminant disease, some of which are zoonotic. The aim of this study was to describe the pathological, immunohistochemical, and molecular findings associated with the occurrence of a previously unreported *Chlamydia* sp infection causing a major mortality event in farmed American alligators (*Alligator mississippiensis*). The outbreak presented with sudden death in juvenile alligators mainly associated with necrotizing hepatitis and myocarditis, followed by the occurrence of conjunctivitis after the initial high mortality event. The widespread inflammatory lesions in multiple organs correlated with intralosomal chlamydial organisms identified via immunohistochemistry and confirmed by 23S rRNA-specific real-time quantitative polymerase chain reaction (qPCR) for Chlamydiaceae bacteria. By sequencing and phylogenetic analysis of the OmpA gene, this uncultured *Chlamydia* sp grouped closely with *Chlamydia poikilothermis* recently described in snakes. This study highlights the significance of such outbreaks in farmed populations. Enhanced epidemiological monitoring is needed to gain further insight into the biology of

*Chlamydia* sp in alligators, disease dynamics, risk factors, and role of carrier animals.

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Alexakis, E. and Janiszewski, L. (2022). Greek Australians in their own image: George Haritos - Crocodile Man. Greek City Times, 10 April 2022 (<https://greekcitytimes.com/2022/04/10/greek-australians-in-their-own-image-george-haritos-crocodile-man/>).

**Abstract:** The need for a sense of adventure has drawn Greeks into both exploring and utilising the commercial potential of Australian waters - one such adventurer was George Haritos. Haritos was not only a successful coastal barge captain, barramundi fisherman and pearler, but also a water-buffalo hunter and crocodile shooter.

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Guyot, N., Landon, C. and Monget, P. (2022). The two domains of the avian double- $\beta$ -defensin AvBD11 have different ancestors, common with potential monodomain crocodile and turtle defensins. *Biology* 11(5): 690 (doi: [10.3390/biology11050690](https://doi.org/10.3390/biology11050690)).

**Abstract:** Beta-defensins are an essential group of cysteine-rich host-defence peptides involved in vertebrate innate immunity and are generally monodomain. Among bird defensins, the avian  $\beta$ -defensin 11 (AvBD11) is unique because of its peculiar structure composed of two  $\beta$ -defensin domains. The reasons for the appearance of such 'polydefensins' during the evolution of several, but not all branches of vertebrates, still remain an open question. In this study, we aimed at exploring the origin and evolution of the bird AvBD11 using a phylogenetic approach. Although they are homologous, the N- and C-terminal domains of AvBD11 share low protein sequence similarity and possess different cysteine spacing patterns. Interestingly, strong variations in charge properties can be observed on the C-terminal domain depending on bird species but, despite this feature, no positive selection was detected on the AvBD11 gene (neither on site nor on branches). The comparison of AvBD11 protein sequences in different bird species, however, suggests that some amino acid residues may have undergone convergent evolution. The phylogenetic tree of avian defensins revealed that each domain of AvBD11 is distant from ovodefensins (OvoDs) and may have arisen from different ancestral defensins. Strikingly, our phylogenetic analysis demonstrated that each domain of AvBD11 has common ancestors with different putative monodomain  $\beta$ -defensins from crocodiles and turtles and are even more closely related with these reptilian defensins than with their avian paralogs. Our findings support that AvBD11's domains, which differ in their cysteine spacing and charge distribution, do not result from a recent internal duplication but most likely originate from a fusion of two different ancestral genes or from an ancestral double-defensin arisen before the Testudines-Archosauria split.

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Sadlok, G. (2022). Carnivorous reptile feeding strategies and postmortem food-processing behaviors: tooth traces on bones from the Upper Triassic Grabowa Formation (southern Poland). *Journal of Paleontology* (doi: <https://doi.org/10.1017/jpa.2022.16>).

**Abstract:** Carnivores make traces on bones with their teeth when feeding. A true predatory bite trace (predichnia) forms when a predator catches and kills its prey or attempts to do so. Both predators and scavengers may leave their nonpredatory feeding traces during postmortem food processing. Despite the interpretative uncertainties as to the ethology such ichnofossils may represent, the bite traces have been traditionally classified as predichnia - traces of predation. Previously, there was no alternative ethological category available for workers to classify them. The present paper fills that gap and describes tooth-made ichnofossils from the continental Upper Triassic Grabowa Formation of southern Poland. It discusses modes the serration and striations might have formed along Linichnus edges, potential makers of the trace fossils, feeding strategies, and food-processing behaviors the ichnites may represent. All the bite traces are thought to act as a record of carnivorous behaviors

and are classified as sarcophagichnia, a new ethological category (traces of feeding on a body). Finally, all the studied bite traces were likely inflicted postmortem and are classified as necrophagichnia (traces of feeding on an already dead body), most likely produced by scavengers in the studied cases. Data on recent carnivores link these ichnites with postmortem food-processing behaviors, such as dismembering and defleshing. Scavenging could, in fact, have been a preferred carnivorous feeding strategy in the seasonal Norian climate of the area. Dry seasons could have perhaps increased vertebrate mortality rates and provided plenty of carcasses for carnivores to feed on.

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Islam, F., Leung, K.K., Walker, M.D., Al Massri, S. and Shilton, B.H. (2022). The unusual cosubstrate specificity of NQO2: Conservation throughout the amniotes and implications for cellular function. *Frontiers in Pharmacology* (doi: [10.3389/fphar.2022.838500](https://doi.org/10.3389/fphar.2022.838500)).

**Abstract:** Human Quinone Reductase 2 (NQO2) is a pharmacological target and has appeared in numerous screening efforts as an off-target interactor with kinase-targeted drugs. However the cellular functions of NQO2 are not known. To gain insight into the potential cellular functions of NQO2, we have carried out a detailed evolutionary analysis. One of the most striking characteristics of NQO2 is that it uses conventional dihydronicotinamide cosubstrates, NADH and NADPH, extremely inefficiently, raising questions about an enzymatic function in cells. To characterize the ability of NQO2 to serve as an enzyme, the NQO2 gene was disrupted in HCT116 cells. These NQO2 knockouts along with the parental cells were used to demonstrate that cellular NQO2 is unable to catalyze the activation of the DNA cross-linking reagent, CB1954, without the addition of exogenous dihydronicotinamide riboside (NRH). To find whether the unusual cosubstrate specificity of NQO2 has been conserved in the amniotes, recombinant NQO2 from a reptile, *Alligator mississippiensis*, and a bird, *Anas platyrhynchos*, were cloned, purified, and their catalytic activity characterized. Like the mammalian enzymes, the reptile and bird NQO2 were efficient catalysts with the small and synthetic cosubstrate N-benzyl-1,4-dihydronicotinamide but were inefficient in their use of NADH and NADPH. Therefore, the unusual cosubstrate preference of NQO2 appears to be conserved throughout the amniotes; however, we found that NQO2 is not well-conserved in the amphibians. A phylogenetic analysis indicates that NQO1 and NQO2 diverged at the time, approximately 450 MYA, when tetrapods were beginning to evolve.

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Davidian, A.G., Dyomin, A.G., Galkina, S.A., Makarova, N.E., Dmitriev, S.E. and Gaginskaya, E.R. (2022). 45S rDNA repeats of turtles and crocodiles harbor a functional 5S rRNA gene specifically expressed in oocytes. *Molecular Biology and Evolution* 39(1) (doi: [10.1093/molbev/msab324](https://doi.org/10.1093/molbev/msab324)).

**Abstract:** In most eukaryotic genomes, tandemly repeated copies of 5S rRNA genes are clustered outside the nucleolus organizer region (NOR), which normally encodes three other major rRNAs: 18S, 5.8S, and 28S. Our analysis of turtle rDNA sequences has revealed a 5S rDNA insertion into the NOR intergenic spacer in antisense orientation. The insertion (hereafter called NOR-5S rRNA gene) has a length of 119 bp and coexists with the canonical 5S rDNA clusters outside the NOR. Despite the ~20% nucleotide difference between the two 5S gene sequences, their internal control regions for RNA polymerase III are similar. Using the turtle *Trachemys scripta* as a model species, we showed the NOR-5S rDNA specific expression in oocytes. This expression is concurrent with the NOR rDNA amplification during oocyte growth. We show that in vitellogenic oocytes, the NOR-5S rRNA prevails over the canonical 5S rRNA in the ribosomes, suggesting a role of modified ribosomes in oocyte-specific translation. The orders Testudines and Crocodylia seem to be the only taxa of vertebrates with such a peculiar rDNA organization. We speculate that the amplification of the 5S rRNA genes as a part of the NOR DNA during oogenesis provides a dosage balance between

transcription of all the four ribosomal RNAs while producing a maternal pool of extra ribosomes. We further hypothesize that the NOR-5S rDNA insertion appeared in the Archelosauria clade during the Permian period and was lost later in the ancestors of Aves.

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Knoll, F., Lautenschlager, S., Kawabe, S., Martínez, G., Espílez, E., Mampel, L. and Alcalá, L. (2021). Palaeoneurology of the early cretaceous iguanodont *Proa valdearinnensis* and its bearing on the parallel developments of cognitive abilities in theropod and ornithopod dinosaurs. *Journal of Comparative Neurology* 529(18): 3922-3945.

**Abstract:** *Proa valdearinnensis* is a relatively large-headed and stocky iguanodontian dinosaur from the latest Early Cretaceous of Spain. Its braincase is known from three specimens. Similar to that of other dinosaurs, it shows a mosaic ossification pattern in which most of the bones seem to have fused together indistinguishably while a few (frontoparietal, basioccipital) might have remained loosely attached. The endocasts of the three specimens are described based on CT data and digital reconstructions. They show unmistakable morphological similarities with the endocast of closely related taxa, such as *Sirindhorna khoratensis* (which is close in age but from Thailand). This supports a high conservatism of the endocranial cavity. The issue of volumetric correspondence between endocranial cavity and brain in dinosaurs is analyzed. Although a brain-to-endocranial cavity (BEC) index of 0.50 has been traditionally used, we employ instead 0.73. This is indeed the mid-value between the situation in adults of *Alligator mississippiensis* and *Gallus gallus*, which are members of the extant bracketing taxa of dinosaurs (Crocodylia and Aves). We thence gauge the level of encephalization of *P. valdearinnensis* through the calculation of the encephalization quotient (EQ), which remains valuable as a metric for assessing the degree of cognitive function in extinct taxa, especially those with fully ossified braincases like dinosaurs and other archosaurs. The EQ obtained for *P. valdearinnensis* (3.611) suggests that this species was significantly more encephalized than most if not all extant nonavian, nonmammalian amniotes. Our work adds to the growing body of data concerning theoretical cognitive capabilities in dinosaurs and supports the idea that an increasing encephalization was fostered not only in theropods but also in parallel in the shorter-lived lineage of ornithopods. *P. valdearinnensis* was ill-equipped to respond to theropod dinosaurs and possibly lived in groups as a strategy to mitigate the risk of being predated upon. We hypothesize that group-living and protracted caring of juveniles in this and possibly many other iguanodontian ornithopods favored a degree of encephalization that was outstanding by reptile standards.

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Hertzog, J., Fujii, H., Žostautaitė, R., Lattuati-Derieux, A., Richardin, P., Carré, V., Aubriet, F. and Schmitt-Kopplin P. (2022). Unravelling the Egyptian embalming materials by a multi-method approach comprising high-resolution mass spectrometry. Available at SSRN: <https://ssrn.com/abstract=4098910> or <http://dx.doi.org/10.2139/ssrn.4098910>.

**Abstract:** Mummification balms are considered among the best-preserved organic archaeological samples. Therefore, deciphering their composition can contribute to increasing our knowledge about the status of the buried person and the habits of the corresponding civilization. It also makes it possible to estimate the state of degradation of the sample. The determination of the organic substances involved in the embalming material is based on identifying biomarkers, which is commonly carried out by gas chromatography-mass spectrometry (GC-MS). Here high-resolution Fourier transform ion cyclotron resonance mass spectrometry (FT-ICR MS) was used, along with gas chromatography-mass spectrometry and infrared spectroscopy, to investigate the organics of embalming material of Egyptian crocodile mummies. FT-ICR MS differentiated and assigned thousands of molecular contributions comprising potential new biomarkers. Thus, pine resin, beeswax, and vegetal and animal fat were suggested, which was confirmed by

GC-MS. Eventually, the FT-ICR MS molecular fingerprint obtained for the archaeological samples was compared with those of modern pine resin, which allowed for assessing the ageing and heating process.

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IUCN (2022). Application of Indigenous & Local Knowledge (ILK) in IUCN Red List Assessments: White paper. Version 1. Adopted by the IUCN SSC Red List Committee and IUCN CEESP-SSC Sustainable Use & Livelihoods Specialist Group Steering Committee. (<https://www.iucnredlist.org/resources/ilk>).

**Executive Summary:** Indigenous and Local Knowledge (ILK) has been developed over centuries or millennia by indigenous peoples and local communities (IPLCs) and is continuously evolving. It provides a unique and rich source of information on biodiversity and also represents an important aspect of human cultural, and behavioural diversity. There has been increasing recognition over recent years that ILK has an important role to play in environmental decision-making, management, policy, and assessments. Application of ILK into formal scientific processes increases the likelihood that these processes are comprehensive and informed by the best available information. Historically, elements of ILK have frequently been described by visiting scientists and others, but often in a piecemeal way, or with information misunderstood or synthesised, and without attribution. This situation has improved in recent years, although application of ILK in Red List assessments has been limited to date, at least as specifically accredited, although some information from ILK holders may be included within cited reports and publications. This document examines the issues and general principles surrounding the application of indigenous and local knowledge (ILK) in the IUCN Red List and outlines some key steps. The document builds on discussions that have taken place over the last decade between the IUCN CEESP-SSC Sustainable Use and Livelihoods Specialist Group and the IUCN SSC Red List Committee and draws on experience from the IPBES ILK Approach. ILK and science are different 'knowledge systems' that share some characteristics and should be seen as complementary. ILK has an equal value and is applied like information from other sources or knowledge systems, using the same SIS fields in the Red List process. However, the ways that ILK is accessed will vary, requiring a flexible approach. There are no a priori barriers in principle to applying ILK in the Red List which treats information from all knowledge systems equally. However, accessing ILK is not straightforward and a considered and sensitive approach to IPLCs is required, which poses some practical and logistical challenges. A concerted programme by IUCN (Red List Committee, SULi, CEESP, others) together with major partners, is needed to ensure comprehensive and effective application of ILK in Red List assessments.

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Makumbe, P., Mapurazi, S., Jaravani, S. and Matsilele, I. (2022). Human-Wildlife Conflict in Save Valley Conservancy: Residents' attitude toward wildlife conservation. *Scientifica (Cairo)* (doi: 10.1155/2022/2107711).

**Abstract:** Human settlement in protected areas (PAs) is a major conservation concern in developing nations as it fuels human-wildlife conflicts (HWCs). The objectives of this study were to (i) determine the key wildlife species causing conflict, (ii) assess the perceptions of residents toward the major causes of conflict with wildlife, and (iii) evaluate the attitudes of residents toward problem animals. We conducted face-to-face semistructured interviews and two reconnaissance field surveys with 290 respondents residing in Save Valley Conservancy (SVC), in Southeast Lowveld Zimbabwe from January 2014 to June 2014. Results showed that lions (*Panthera leo*), spotted hyenas (*Crocuta crocuta*), elephants (*Loxodonta africana*) and Nile crocodiles (*Crocodylus niloticus*) were the major animals involved in the conflict. Our results also showed that the land-use change from wildlife ranching to farming and contested land ownership were perceived as the major causes of HWCs. Respondents who had lived in the area longer were more

likely to agree that change in land use (Ordinal logistic regression:  $B = 1.32$ , Odds Ratio (OR) = 3.74) and contested land ownership ( $B = .67$ , OR = 1.95) were major sources of conflict. In addition, increased encounters between people and wildlife triggered mixed attitudes toward problem animals. For example, males were less likely to have a negative attitude toward problem animals compared to females (Multinomial logistic regression:  $B = -1.39$ ; OR = .25). Residents who had stayed for less than five years were more likely to have a negative attitude toward problem animals than those who had stayed longer ( $B = 3.6$ ; OR = 36.71). These results suggest that there is a need to relook at the resettlement pattern because coordinating HWCs and implementing sustainable conservation objectives are easy in a well-planned settlement. Stakeholders need to come together and create awareness of the use of HWCs mitigations measures.

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Achatz, T.J., Chermak, T.P., Junker, K. and Tkach, V.V. (2022). Integration of morphological and molecular data reveals further unknown diversity of the Proterodiplostomidae in crocodylians. *Systematics and Biodiversity* 20(1) (<https://doi.org/10.1080/14772000.2022.2051212>).

**Abstract:** The Proterodiplostomidae Dubois, 1936 is a family of digeneans within the superfamily Diplostomoidea Poirier, 1886. Members of the family are distributed mostly in the tropics and subtropics, primarily in crocodylians, although some species are known from other reptiles. Despite their broad geographic distribution, the knowledge of proterodiplostomid diversity remains limited, mostly because a number of potential host species and regions of the world have not been sufficiently explored for these parasites. In this study, we use morphological and molecular data to describe four new genera (*Afroproterodiplostomum* gen. nov., *Dungalabatrema* gen. nov., *Australiadiplostomum* gen. nov. and *Nattererodiplostomum* gen. nov.) and five new species (*Afroproterodiplostomum ingwenyae* sp. nov., *Australiadiplostomum blairi* sp. nov., *Dungalabatrema kostadinovae* sp. nov., *Dungalabatrema snyderi* sp. nov. and *Pseudoneodiplostomum angustus* sp. nov.) of proterodiplostomids from crocodylians in Australia, South Africa and South America. *Nattererodiplostomum* gen. nov. has been established upon re-evaluation of the status of *Proterodiplostomum medusae* (Dubois, 1936) from caimans in Brazil using combined morphological and molecular evidence. Only a few previous studies provided DNA sequence data of proterodiplostomids. We generated partial 28S rDNA and cytochrome c subunit (cox1) mtDNA sequences for three previously undescribed proterodiplostomids collected from *Crocodylus* spp. in Australia and South Africa. The newly generated 28S sequences were used to examine phylogenetic affinities of these taxa. All three newly sequenced proterodiplostomid species appeared in the phylogenetic tree in a strongly supported monophyletic clade comprising exclusively parasites of *Crocodylus*.

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Choudhary, R., Chand, S., Singh, T., Singhal, R.K., Chourasiya, V.K. and Indu. (2022). Sex determination. In *Genetic Polymorphisms - New Insights*, edited by M. Çalıřkan. IntechOpen: London.

**Abstract:** A wide array of sex determination mechanisms, encompassing genetic and non-genetic pathways (ie hormonal, environmental, and epigenetic factors), have been found among different organisms. The presence of two complementary sexes, male and female, is an ancient feature in biology. Triggering the differentiation of male and female reproductive organs is a conserved ontogenic process, and sex determination is an inherently fascinating process. Sex determination is dependent on molecular signaling whether the male and the female differentiating pathway is activated, and different triggering elements such as genetic, non-genetic, and epigenetic factors control the whole process. This chapter describes various aspects of sex determination, such as historical development, the evolution of sex chromosomes, and different sex determination systems in other organisms.

Hariyanto, O.I.B. (2022). Cultural tourism: The meaning and symbol of crocodile bread in Betawi traditional marriage. In *Current Issues in Tourism, Gastronomy, and Tourist Destination Research*, ed. by H. Oktadiana, M. Rahmanita, R. Suprina and P. Junyang. Routledge: London.

**Abstract:** Indonesian people have a diversity of culture, ethnicity, religion, language, and custom that enriches local wisdom. In addition, the human life cycle tradition of Indonesian ethnic groups can be a tourist object and attraction. One of the examples of the tradition is the marriage tradition of the Betawi ethnic group with the bridewealth (Seserahan) of 'crocodile' bread as a symbol to express the groom's faithful promise, patience, and responsibility for protecting his family. Therefore, this research aimed to reveal the chronology and meaning of the 'crocodile' bread symbol as Seserahan in Betawi marriage tradition. This research was carried out through a descriptive qualitative research method, with a multidisciplinary approach and semiotic studies to analyze the symbols and meanings of 'crocodile' bread based on the local society's perspective. The procession of 'crocodile' bread Seserahan in Betawi marriage tradition can be presented as a tourist object and attraction both for domestic and foreign tourists.

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Salas-Gismondi, R., Ochoa, D., Jouve, S., Romero, P.E., Cardich, J., Perez, A., DeVries, T., Baby, P., Urbina, M. and Carré, M. (2022). Miocene fossils from the southeastern Pacific shed light on the last radiation of marine crocodylians. *Proceedings of the Royal Society B: Biological Sciences* (doi: [10.1098/rspb.2022.0380](https://doi.org/10.1098/rspb.2022.0380)).

**Abstract:** The evolution of crocodylians as sea dwellers remains obscure because living representatives are basically freshwater inhabitants and fossil evidence lacks crucial aspects about crocodylian occupation of marine ecosystems. New fossils from marine deposits of Peru reveal that crocodylians were habitual coastal residents of the southeastern Pacific (SEP) for approximately 14 million years within the Miocene (ca 19 to 5 Ma), an epoch including the highest global peak of marine crocodylian diversity. The assemblage of the SEP comprised two long and slender-snouted (longirostrine) taxa of the Gavialidae: the giant *Piscogavialis* and a new early diverging species, *Sacacosuchus cordovai*. Although living gavialids (*Gavialis* and *Tomistoma*) are freshwater forms, this remarkable fossil record and a suite of evolutionary morphological analyses reveal that the whole evolution of marine crocodylians pertained to the gavialids and their stem relatives (Gavialoidea). This adaptive radiation produced two longirostrine ecomorphs with dissimilar trophic roles in seawaters and involved multiple transmarine dispersals to South America and most landmasses. Marine gavialoids were shallow sea dwellers, and their Cenozoic diversification was influenced by the availability of coastal habitats. Soon after the richness peak of the Miocene, gavialoid crocodylians disappeared from the sea, probably as part of the marine megafauna extinction of the Pliocene.

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Lemaire, J., Brischoux, F., Marquis, O., Mangione, R., Caute, S., Brault-Favrou, M., Churlaud, C. and Bustamante, P. (2022). Relationships between stable isotopes and trace element concentrations in the crocodylian community of French Guiana. *Science of The Total Environment* (<https://doi.org/10.1016/j.scitotenv.2022.155846>).

**Abstract:** Trace elements in the blood of crocodylians and the factors that influence their concentrations are overall poorly documented. However, determination of influencing factors is crucial to assess the relevance of caimans as bioindicators of environmental contamination, and potential toxicological impact of trace elements on these reptiles. In the present study, we determined the concentrations of 14 trace elements (Ag, As, Cd, Cr, Co, Cu, Fe, Hg, Pb, Mn, Ni, Se, V, and Zn) in the blood of four French Guiana caiman species (Spectacled Caiman *Caiman crocodilus* [n = 34], the Black Caiman *Melanosuchus niger* [n = 25], the Dwarf Caiman *Paleosuchus palpebrosus* [n = 5] and the Smooth-fronted Caiman

*Paleosuchus trigonatus* [n= 20]) from 8 different sites, and further investigated the influence of individual body size and stable isotopes as proxies of foraging habitat and trophic position on trace element concentrations. Trophic position was identified to be an important factor influencing trace element concentrations in the four caiman species and explained interspecific variations. These findings highlight the need to consider trophic ecology when crocodylians are used as bioindicators of trace element contamination in environmental studies.

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Grand Pre, C.A., Thielicke, W., Hedrick, B.P., Elsey, R.M. and Schachner, E. (2022). Quantifying movement in ultrasound imagery of the hepatic-piston pulmonary apparatus in the American alligator (*Alligator mississippiensis*). FASEB Journal (doi: [10.1096/fasebj.2022.36.S1.R1941](https://doi.org/10.1096/fasebj.2022.36.S1.R1941)).

**Abstract:** Crocodylians ventilate their lungs using a novel respiratory mechanism called the hepatic-piston apparatus. Previous work presumes that the hepatic-piston pump is facilitated by a smooth thoracodorsal ceiling. However, the sliding and displacement of the pleura has never been confirmed in living crocodylians. Using ultrasound we recorded images of the lung pleura, liver, and viscera freely sliding cranially and caudally in 7 individuals of *Alligator mississippiensis*. Currently, there are no marketed software packages available for use with sonography equipment to quantitatively measure movement in ultrasound videos. To accurately quantify pleural displacement, we used modified cross-correlation functions from PIVlab, an open-source program for particle image velocimetry (PIV). This technology is most often used to trace velocity of particles in fluids. Here we successfully implemented this technology to trace the coherent textures in ultrasound videos and measure lung and visceral displacement. We verified our results with screen captures that included scale bars of the most cranial and caudal positions of the liver during ventilation, a landmark clearly visible in ultrasound. In each animal, 16 second ultrasound videos were collected 1) in a calm, resting state with shallow breaths, and 2) inspiring a 5% CO<sub>2</sub> fixed N<sub>2</sub> gas to invoke deep breathing. Data were collected at an axillary position, a thoracic position, the pleural/hepatic boundary, and a post-hepatic position. The ultrasound recordings show that in every instance, the pleura slides during ventilation. The total displacement varies based on two primary factors: 1) while breathing the 5% CO<sub>2</sub> fixed N<sub>2</sub> gas each individual took deeper breaths and the amount of pleura displacement increased and 2) there is a spatial gradient of displacement cranially to caudally, with minimal movement in the most cranial aspect of the lung and maximum movement caudally.

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Schachner, E.R., Lawson, A.B., Martinez, A., Echols, M.S., Diaz Jr, R.E., Grand Pre, C.A. and Hedrick, B.P. (2022). Intra- and interspecific structural variation in the archosaur lung: insights from 3D imaging and segmentation. FASEB Journal (doi: [10.1096/fasebj.2022.36.S1.R4340](https://doi.org/10.1096/fasebj.2022.36.S1.R4340)).

**Abstract:** Innovations in three-dimensional (3D) imaging and segmentation have facilitated unprecedented levels of anatomical investigation into the detailed structures of the respiratory system that are often difficult to study *in situ*. Recent hypotheses of homology between crocodylians and birds have facilitated quantitative comparative analyses of bronchial trees and *in situ* models reveal new complexities in the relationship between the respiratory and skeletal systems. Here we quantitatively compare the bronchial trees of two crocodylians, the American alligator (*Alligator mississippiensis*) and Cuvier's dwarf caiman (*Paleosuchus palpebrosus*) with select birds, including the ostrich (*Struthio camelus*), the African gray parrot (*Psittacus erithacus*), and the red-tailed hawk (*Buteo jamaicensis*). Notably, the relative distances from the carina to the secondary bronchi measured are conserved, indicating a possible ancestral or constrained trait. With respect to interspecific avian comparisons, we found grossly observable variation within a single taxon in air sac morphology (eg *P. erithacus*), as well as substantial differences between the individual taxa via segmented surface models -

particularly in the expansions of the interclavicular sacs, the extent of the diverticula, and the size of the abdominal sacs. Furthermore, we found that specific sac contribution to postcranial pneumatization varies substantially across our dataset. Individual specimens imaged for this study also revealed multiple pathologies, including scoliosis, foreign objects inside the animals, and broken bones, which have been incorporated into the anatomical models for clinical surgical atlases that are under development. While these data are preliminary, they provide a framework for larger scale comparisons and hypotheses of the ancestral archosaurian pulmonary system.

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Holliday, C.M., Wilken, A., Sellers, K., Cost, I. and Middleton, K. (2022). Flat or flexible? Evolutionary cranial biomechanics and the origins of modern archosaur skulls. FASEB Journal (doi: [10.1096/fasebj.2022.36.S1.R6156](https://doi.org/10.1096/fasebj.2022.36.S1.R6156)).

**Abstract:** The divergent specializations of living archosaurs, crocodylians and birds, represent two of the great transformations in vertebrate evolution. Despite hailing from common ancestor with a tall skull, braced palate and relatively unspecialized jaw muscles, these two living clades followed disparate paths in cranial biomechanics and feeding functional morphology during the Mesozoic era, resulting in the flat, rigid skulls in crocodylians and the bulbous and beaked, flexible skulls of birds. Here we use new approaches in imaging, 3D modeling, morphometrics, lever mechanics, finite element modeling and phylogenetic comparative methods of living and extinct reptiles to show how morphological and functional changes in the palate, cranial joints and jaw musculature occurred within the fossil record of these lineages that were key features in acquisition of the modern forms. We show how jaw muscles reoriented their resultants and moments about jaw joints during skull flattening, palatocranial suturing and feeding specializations in Jurassic crocodyliforms. These morphological changes resulted in a decrease in mechanical efficiency of the feeding apparatus that was compensated for by an increase in jaw muscle sizes and canalized muscle architecture. Meanwhile, along the line to living birds, the acquisition of enlarged brains in coelurosaur dinosaurs resulted in a shifting of temporal and palatal muscle positions, a canalization of vertically-oriented of muscle forces and consequently reorientation of their moments about palatocranial joints. These changes in loading environment, along with a concatenate increase in the propulsive and bending properties of the palate, facilitated cranial kinesis in neoavian birds. Together, these examples of evolutionary innovation in reptile cranial biomechanics reveal powerful new approaches to testing biomechanical and evolutionary hypotheses in any cranial or appendicular musculoskeletal system.

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Ramirez, B.A.S., Sandoval, S., Sparks, J., Elsey, R. and Owerkowicz, T. (2022). Do crocodylians have an air-conditioning unit in their skulls? Experimental test of purported thermoregulatory function of the dorsal temporal fenestrae in the American alligator. FASEB Journal (doi: [10.1096/fasebj.2022.36.S1.R4345](https://doi.org/10.1096/fasebj.2022.36.S1.R4345)).

**Abstract:** The classic view of dorsal temporal fenestrae (DTFs) in diapsids posits that they provide attachment sites for jaw adductor muscles. A recent hypothesis suggested that DTFs in archosaurs may play a role in selective brain thermoregulation, but did not provide supporting experimental data. We tested this hypothesis in two years-old juveniles of the American alligator. We used chronically implanted thermocouples to monitor brain (Tb) and core (Tc) temperatures in constrained but unanaesthetised animals during acute heat exposure. Animals were first equilibrated to either 15°C (n= 9, body mass range 200-563 g) or 30°C (n= 6, body mass range 173-362 g), and then exposed to a radiant heat source (a 75W incandescent light bulb suspended 20 cm above the animal). As experimental treatment, we used insulating covers (custom-made of adhesive foam tape and aluminium foil) to obscure either the DTFs or a corresponding skull surface in subsequent trials. We expected that obscuring the DTF (as opposed to covering the skull roof) would result in Tb rising more slowly in animals at 15°C (ie

interfering with selective brain warming), and would result in Tb rising faster in animals at 30°C (ie interfering with selective brain cooling). We found no statistically significant differences in the rate of brain warming between DTF-covered vs. skull-covered treatments in animals at either 15°C (0.541°C/min vs. 0.683°C/min) or 30°C (0.356°C/min vs. 0.358°C/min). Our results suggest that DTFs, at least in small (<1 kg) alligators, do not function as thermal windows for heat exchange with the environment to afford them selective brain temperature control. However, given that the DTF surface area scales with positive allometry on brain mass ( $Mb^{1.25}$ ) in the American alligator, further experiments are needed to determine whether DTFs acquire a thermoregulatory function in larger crocodylians.

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Morris, Z.S. and Bhullar, B-A. (2022). Patterns of secondary palate convergence across Amniota. *FASEB Journal* (doi: [10.1096/fasebj.2022.36.S1.R1909](https://doi.org/10.1096/fasebj.2022.36.S1.R1909)).

**Abstract:** Living amniotes (mammals, birds, and ‘reptiles’) display a tremendous disparity in craniofacial form and composition, reflecting over 300 million years of evolutionary divergence. The anatomical specialization and ecological diversification of amniotes makes it relatively trivial to distinguish a modern mammal skull from a bird or a turtle from a crocodylian. Despite the anatomical divergences, the roof of the mouth reveals remarkable similarities across these major clades. In fact, mammals, crocodylians, and some lizards have independently derived “secondary palates” which divide the nasal and oral passages (to greater or lesser degrees). However, this conspicuous example of convergent evolution has yet to be characterized in a quantitative analysis. Several critical questions therefore remain poorly understood, including: how convergently similar are “secondary palates”? and are there multiple evolutionary pathways to achieve a “secondary palate”? To begin to address these questions, we captured palate shape using two-dimensional geometric morphometrics from representatives of all extant amniote clades, including all lineages which have been described as possessing “secondary palates”, and key representatives from the fossil record. This landmarking approach allowed for quantifying both the overall shape of the palate but also the key connections among palate elements. These data demonstrate that crocodylians and mammals possess remarkably similar palate anatomy, principally due to the presence of extensive palatal shelves on the maxilla and mid-line contact of the palatines. Other reptiles with putative “secondary palates” do not overlap with crocodylians but rather cluster with other lizards and turtles. There is much greater diversity in palate form observed among squamates, likely reflecting greater functional and/or ecological utility of the palate than in other amniote clades. Extant birds occupy a distinct region of morphospace, potentially reflecting the enlargement of the premaxillary component of the palate. The inclusion of extinct forms reveals that living clades possess substantially modified and derived palate forms compared with ancestral amniotes, regardless of whether they possess “secondary palates” or not. However, several key elements including the ectopterygoid and vomer could not be landmarked due to their absence or exclusion from the ventral surface of the palate in key taxa. There are important differences in the structure and function of the nasal passage among amniote clades, necessitating consideration of other ossified and unossified components when discussing the degree of convergence in palate form and potential explanatory factors. Incorporating the full three-dimensional anatomy of the palate will allow the inclusion of these additional elements and may reveal important nuance to the patterns recovered in this analysis. Future analyses capturing the full volumetric form of individual elements and the entire palate, using a combination of fixed and pseudo landmarks, will be conducted to assess the strength of the patterns recovered here.

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Schwab, J. (2022). Major Evolutionary Transition: Sensory Adaptations of Mesozoic Thalattosuchians and their Extant Crocodylian Relatives. PhD thesis, The University of Edinburgh,

Edinburgh, Scotland, UK (<https://hdl.handle.net/1842/38967>).

**Abstract:** A prime example of a group that underwent a major evolutionary transition are thalattosuchian crocodylomorphs, extinct relatives of modern crocodiles. Known from the Early Jurassic to the Early Cretaceous (ca. 191-125 Ma), they evolved from terrestrial ancestors into the first radiation of marine crocodylomorphs. One thalattosuchians subgroup, teleosauroids, originated in semiaquatic environments with a gharial-like bodyplan, and are known from freshwater, brackish and coastal marine environments. However, the metriorhynchid subgroup radically modified their bauplan during their transition to an obligately pelagic lifestyle, including paddle-shaped limbs, a vertically orientated tail fluke, and a smooth body lacking bony osteoderms. Additionally modifications of their pelvis allowed them to give birth to live young. While these osteological changes are well understood, little is known about how their neurosensory systems adapted during this transition. Cranial sensory organs recognisable in fossils, such as the bony labyrinth of the inner ear and brain endocasts, are powerful ecological proxies that can be correlated with animal behaviour and lifestyles. Underpinning this thesis is a wealth of new data from computed tomography (CT) scanning of extinct and extant crocodylomorphs, which allows a better insight and understanding of cranial sensory systems and how their anatomy, morphology and physiology changed during a major evolutionary transition. This thesis consists of two parts, first how sensory systems changed and adapted during the transition of thalattosuchians into the open ocean (Chapters II, III and IV), and secondly on the ontogeny of the bony labyrinth and otoliths of modern crocodylians (Chapters V and VI) in relation to thalattosuchians. Chapter II, describes the braincase and endocranial anatomy of the Middle Jurassic metriorhynchid, ‘*Metriorhynchus*’ cf. ‘*M. brachyrhynchus*’ (NHMUK PV OR 32617). Three-dimensionally rendered neuroanatomical features, such as the bony labyrinth, brain endocast, sinuses and cranial nerves provide an insight into how thalattosuchians adapted their sensory systems to their new ocean environment. Neuroanatomical adaptations of the specimen include a unique brain flexure, enlarged cerebral hemispheres, rounded pituitary fossa, enlarged internal carotid arteries, hypertrophied venous sinus and pelagic labyrinth morphology. Some of these features evolved early in thalattosuchians and helped them adapt to their new ocean environment. Chapters III and IV focus on the ecomorphological changes of two endocranial systems, the bony endocast of the inner ear and of the brain. Both represent crucial sensory system that can give insights into the lifestyle and behaviour of ancient animals. Based on CT-scans and three-dimensional models, multivariate analysis were used to quantitatively describe morphological changes. Bony labyrinths shows three different morphologies in crocodylomorphs (terrestrial, semiaquatic and pelagic), with pelagic metriorhynchids having a dorsoventrally shorter and more compact labyrinth, and larger canal diameters. Similarly, metriorhynchids also modified their brain endocast, and developed an expanded cerebrum, rounded hindbrain, compressed medulla, larger/rounded pituitary fossa and most importantly a smaller optic lobe, compared to semiaquatic taxa. This is somewhat similar to changes observed in other marine reptiles, however those sensory adaptations only occurred after they already modified their bodyplan and were likely a response to their new ocean habitat and not leading the transition. Chapter V, focuses on ontogenetic differences in the vestibular system of modern crocodylians. Body size, skull dimensions, bite force and neurosensory systems change drastically during ontogeny. Based on CT-scans and three-dimensional geometric morphometrics of 30 crocodylian labyrinths the size and shape changes throughout ontogeny were investigated, across four stages, hatchling, juvenile, subadult, and adult. There are two major shifts happening in the crocodylian labyrinth. First, it changes in size during ontogeny with negative allometry in relation to skull size. Second, a morphological change occurs, with hatchlings having shorter semicircular canal radii, thicker canal diameters, and an overall dorsoventrally shorter labyrinth than those of more mature individuals. It can be proposed that those changes are likely driven by constraints imposed by skull growth, due to the morphological change of the braincase (eg verticalization of the

basicranium) rather than changes in locomotion, diet, or behaviour. Chapter VI, describes the presence of ‘ear stones’ or otoliths in the vestibule of crocodylians. Those are biomineralised structures that are well known from fish, but have not been studied in detail in most tetrapods. This chapter describes for the first time in detail the otoliths of crocodylians. They are monocrystalline structures present in all three major crocodylian lineages (Alligatoridae, Crocodylidae and Gavialidae) and grow with positive allometry in relation to skull size. This suggests that they play an important role in sensory detection (eg hearing, balance and behaviour) and need to be examined in further detail across all tetrapods. Overall the results of this thesis show that endocranial sensory systems can help answer key questions on major evolutionary transitions and played an important role for these unique ancient crocodylomorphs to adapt to their ocean realm.

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Mujal, E., Foth, C., Maxwell, E.E., Seegis, D. and Schoch, R.R. (2022). Feeding habits of the Middle Triassic pseudosuchian *Batrachotomus kupferzellensis* from Germany and palaeoecological implications for archosaurs. *Palaeontology* 2022: e12597.

**Abstract:** Bite traces on fossil bones are key to deciphering feeding ecology and trophic interactions of vertebrate past ecosystems. However, similarities between traces produced by different carnivorous taxa with similar dentitions, and misidentifications due to equifinality, hinder confident identifications of the bite makers. Here, we correlate bite traces with macroscopic wear and microanatomy of the teeth of the pseudosuchian archosaur *Batrachotomus kupferzellensis* from the Triassic Lower Keuper fossil lagerstätten (southern Germany), untangling its feeding habits and shedding light on the bite traces generated by ziphodont teeth (teeth with serrated carinae). Individually, bite traces reflect tooth morphology, whereas composite bite traces and their frequency are related to feeding behaviour and explain tooth macroscopic wear and microanatomy. Therefore the identification of the bite maker is possible by analysing composite bite traces, their location on bones, and their relative abundance. In addition, tooth macroscopic wear and microanatomy are proven as independent lines of evidence of feeding ecology. Comparing bite traces on fossil and present-day bone assemblages, we observe that bone modifications by the crocodylomorph lineage (from Triassic pseudosuchian archosaurs to extinct and extant crocodylians) are strikingly similar, including taxa with and without ziphodont teeth. Such a set of features differs from bone modification assemblages produced by taxa with similar ziphodont teeth outside the pseudosuchian lineage, such as theropod dinosaurs and the Komodo monitor, suggesting phylogeny is a better predictor of feeding ecology among saurian reptiles than tooth morphology.

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Brownstein, C.D. (2022). High morphological disparity in a bizarre Paleocene fauna of predatory freshwater reptiles. *BMC Ecology and Evolution* 22(1): 34.

**Abstract:** The consequences of the K-Pg mass extinction are reflected across present biodiversity, but many faunas that appeared immediately after the extinction event were very different from current ones. Choristodera is a clade of reptiles of uncertain phylogenetic placement that have an extremely poor fossil record throughout their 150-million-year history. Yet, choristoderes survived the K-Pg event and persisted until the Miocene. I describe the skulls and skeletons of two new choristoderes from a single Paleocene ecosystem in western North America that reveal the hidden Cenozoic diversity of this reptile clade. Despite their similar size, the new species deviate dramatically in morphology. *Kosmodraco magnicornis* gen. et sp. nov. possesses an extremely short snout and extensive cranial ornamentation. The sacrum of *K. magnicornis* bears enlarged muscle attachment sites and other modifications reminiscent of some giant crocodylians. In contrast, *Champsosaurus norelli* sp. nov. is a longirostrine species with an uninflated and ventrally divergent postorbital skull. Together with a

North American choristodere previously classified in the European genus *Simoedosaurus*, *K. magnicornis* substantiates a new clade of giant, short-snouted taxa endemic to the Americas. *C. norelli* is found to be an early-diverging member of the genus *Champsosaurus* from the Cretaceous-Paleogene of the northern hemisphere. This suggests the presence of several ghost lineages of champsosaurid that crossed the K-Pg boundary. The new taxa greatly increase Cenozoic choristodere richness and strengthen the evidence for the existence of distinctive freshwater faunas in Paleogene Eurasia and North America, where this clade diversified to exploit newly available macropredatory niches in the aftermath of the asteroid impact. The new choristoderes also reveal the distinct ecological context in which extant freshwater predators of the Americas like alligatoroids and gars have their origins: Paleocene fluviolacustrine ecosystems in North America displayed high large predator diversity and morphological disparity relative to modern ones.

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Pérez Ortiz, B.A. (2021). Aproximación al estado de conocimiento de *Caiman crocodilus* Linnaeus, 1758 en Colombia. BSc thesis, Universidad Distrital Francisco José de Caldas, Bogotá, Colombia.

**Abstract:** *Caiman crocodilus* is a species of alligator that is distributed throughout the American continent, from the southern United States to the north of Bolivia. It currently has three valid subspecies *C. crocodilus fuscus*, *C. crocodilus chiapasius* and *C. crocodilus crocodilus*, because it was recently described that the subspecies *C. crocodilus apaporiensis* really is a morphological variation of the subspecies *C. c. crocodilus*. This species is commonly called as ‘‘spectacled caiman’’ due to the edge that forms in the anterior part of its eyes, in Colombia it is known as ‘‘Babilla’’ and is usually recognized in practically all the departments of the country due to its commercial use and its extensive distribution. Despite the recognition of the species throughout the territory, its study focuses on production, trade, and use, leaving aside its study in wild populations and its interaction and importance in the habitats in which it is present, therefore, a bibliographic review is necessary to evaluate the state of knowledge of the species in Colombia and effectively understand the key points for its use and conservation. To achieve this, an exhaustive review of databases, research tools, web pages, software was carried out and a map of the current distribution of the species was generated. 198 documents associated with the species were collected and divided into the following categories: general, application and use, conservation, distribution, ecology and systematics. Most of the information was associated with the category of application and use. The results indicate that most of the documents at the regional level come from the Caribbean, where zoocria processes are largely developed. It seems that the main interest generated by the species is its commercial value which makes it essential to prioritize studies in the wild because, although the species is not threatened, its historical mismanagement could be affecting its conservation.

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Ruethers, T., Nugraha, R., Taki, A.C., O’Malley, A., Karnaneedi, S., Zhang, S., Kapingidza, A.B., Mehr, S., Kamath, S.D., Chruszcz, M., Mackay, G., Campbell, D.E. and Lopata, A.L. (2022). The first reptilian allergen and major allergen for fish-allergic patients: Crocodile  $\beta$ -parvalbumin. *Pediatric Allergy and Immunology* 33: e13781.

**Abstract:** Clinical cross-reactivity between bony fish, cartilaginous fish, frog, and chicken muscle has previously been demonstrated in fish-allergic patients. In indicative studies, two reports of anaphylaxis following the consumption of crocodile meat and IgE-cross-binding were linked to the major fish allergen parvalbumin (PV). This study investigates IgE-binding proteins in crocodile meat with a focus on PV and their clinical relevance. Proteins were extracted from muscle tissue of crocodile, three bony fish, and two cartilaginous fish. A cohort of fish-allergic pediatric patients (n= 77) underwent allergen skin prick testing (SPT) to three fish preparations (n= 77) and crocodile (n= 12). IgE-binding proteins were identified

and quantified by SDS-PAGE, mass spectrometric analyses, and immunoblotting using commercial and in-house antibodies, as well as individual and pooled patients' serum. PV isoforms were purified or recombinantly expressed before immunological analyses, including human mast cell degranulation assay. Of the tissues analyzed, PV was most abundant in heated crocodile preparation, triggering an SPT of  $\geq 3$  mm in 8 of 12 (67%) fish-allergic patients. Seventy percent (31 of 44) of fish PV-sensitized patients demonstrated IgE-binding to crocodile PV. Crocodile  $\beta$ -PV was the major IgE-binding protein but 20-fold less abundant than  $\alpha$ -PV. Cellular reactivity was demonstrated for  $\beta$ -PV and epitopes predicted, explaining frequent IgE-cross-binding of  $\beta$ -PVs. Both PV isoforms are now registered as the first reptile allergens with the WHO/IUIS ( $\beta$ -PV as Cro p 1 and  $\alpha$ -PV as Cro p 2). Fish-allergic individuals may be at risk of an allergy to crocodile and should seek specialist advice before consuming crocodilian meat.

Nie, H., Wen, Y., Zhang, R., Wu, M., Zhang, Y., Xu, Y., Zhan, J. and Wu, X. (2022). Histology, ultrastructure, and differential gene expression in relation to seasonal sperm storage in the oviduct of the Chinese alligator, *Alligator sinensis*. *Reproduction, Fertility and Development* (doi: 10.1071/RD21191).

**Abstract:** Although oviductal sperm storage are essential steps in reproduction for female animals with internal fertilisation, no systematic study on the identification of genes involving sperm storage has been performed in crocodilian species. In the present research, the relationship between morphological variation related to sperm storage in the oviduct and gene expression patterns derived from RNA sequencing analyses between active period (AP), breeding period (BP), and hibernation period (HP) were investigated. The corresponding results indicated that sperm were observed not only in the ciliated cells within infundibulum and mucosal layer of uterus during BP, but also been detected in the spermatosome storage tube (SST) in the anterior uterus at HP stage. The further transmission electron microscopy analysis indicated that the differences in the number and activity of the secretory cells likely to attributed to the seasonal variation of microenvironment related to the sperm storage. Based on the RNA-sequencing, 13147 DEGs related to the Peroxisome proliferator-activated receptors (PPARs) and FOXO signalling were identified, including these, the down-regulated ATG12 and BCL2L11 in the HP group may thus constitute an important point of convergence between autophagy and apoptosis involving the FOXO1 pathway. The genes involved in the PPARs pathway might modulate the immune response and thereby contribute to prolong the life span of stored spermatozoa in *Alligator sinensis*. The outcomes of this study provide fundamental insights into the mechanism of sperm storage in *A. sinensis*.

Humphries, M., Myburgh, J., Campbell, R. and Combrink, X. (2022). High lead exposure and clinical signs of toxicosis in wild Nile crocodiles (*Crocodylus niloticus*) from a World Heritage Site: Lake St Lucia Estuarine System, South Africa. *Chemosphere* 303 (https://doi.org/10.1016/j.chemosphere.2022.134977).

**Abstract:** Lead (Pb) exposure is a widespread wildlife conservation threat, but impacts on reptile populations remain poorly documented. In this study, we examined Pb exposure and accumulation in a wild population of Nile crocodiles (*Crocodylus niloticus*) at Lake St Lucia, South Africa. Recreational angling has occurred in the area since the 1930s and incidental ingestion of Pb fishing weights has previously been identified as a major source of Pb poisoning in the local crocodile population. In 2019, we sampled blood and tail fat tissues from wild (n= 22) and captive (n= 3) crocodiles at Lake St Lucia to investigate potential impacts of chronic Pb exposure on crocodilian health. Lead was detected in blood samples of all wild crocodiles, although concentrations varied widely between individuals (86-13100 ng ml<sup>-1</sup>). The incidence of Pb poisoning was higher in male crocodiles, with mean blood lead (BPb) levels in males (3780  $\pm$  4690 ng ml<sup>-1</sup>) significantly (p<0.001) higher

compared to females (266  $\pm$  230 ng ml<sup>-1</sup>). Blood Pb levels were correlated with concentrations measured in tail fat tissue (n.d.-4175 ng g<sup>-1</sup> wet wt). Although most of the crocodiles sampled appeared to be in good physical condition, highly elevated BPb levels (>6000 ng ml<sup>-1</sup>) were associated with markedly suppressed packed cell volumes (4.6-10.8%) and severe deterioration in tooth condition. These findings suggest that anaemia and tooth loss may be clinical signs of long-term environmental exposure to Pb. Although previously undocumented in crocodilians, these symptoms are consistent with Pb poisoning observed in birds and mammals, and suggest that crocodilians may be more susceptible to the long-term toxic effects of Pb than previously thought. In light of these findings, we suggest that the impact of accumulated Pb on crocodilian fitness, reproduction and mortality requires urgent attention.

Cuff, A.R., Demuth, O.E., Michel, K., Otero, A., Pintore, R., Polet, D.T., Wiseman, A.L.A. and Hutchinson, J.R. (2022). Walking and running and jumping with dinosaurs and their cousins, viewed through the lens of evolutionary biomechanics. *Integrative and Comparative Biology* (doi: 10.1093/icb/icac049).

**Abstract:** Archosauria diversified throughout the Triassic Period before experiencing two mass extinctions near its end ~201 Mya, leaving only the crocodile-lineage (Crocodylomorpha) and bird-lineage (Dinosauria) as survivors; along with the pterosaurian flying reptiles. About 50 years ago, the “locomotor superiority hypothesis” (LSH) proposed that dinosaurs ultimately dominated by the Early Jurassic Period because their locomotion was superior to other archosaurs’. This idea has been debated continuously since, with taxonomic and morphological analyses suggesting dinosaurs were “lucky” rather than surviving due to being biologically superior. However, the LSH has never been tested biomechanically. Here we present integration of experimental data from locomotion in extant archosaurs with inverse and predictive simulations of the same behaviours using musculoskeletal models, showing that we can reliably predict how extant archosaurs walk, run and jump. These simulations have been guiding predictive simulations of extinct archosaurs to estimate how they moved, and we show our progress in that endeavour. The musculoskeletal models used in these simulations can also be used for simpler analyses of form and function such as muscle moment arms, which inform us about more basic biomechanical similarities and differences between archosaurs. Placing all these data into an evolutionary and biomechanical context, we take a fresh look at the LSH as part of a critical review of competing hypotheses for why dinosaurs (and a few other archosaur clades) survived the Late Triassic extinctions. Early dinosaurs had some quantifiable differences in locomotor function and performance vs. some other archosaurs, but other derived dinosaurian features (eg metabolic or growth rates, ventilatory abilities) are not necessarily mutually exclusive from the LSH; or maybe even an opportunistic replacement hypothesis; in explaining dinosaurs’ success.

Tahara, R. and Larsson, H.C.E. (2022). Paratympanic sinuses in juvenile alligator. *Anatomical Record* (Hoboken) (doi: 10.1002/ar.24932).

**Abstract:** Crocodylia has an extensive epithelial pneumatic space in the middle ear, paratympanic sinus system. Although fossil and extant crocodylian paratympanic sinus systems have been studied recently using the computed tomography (CT) and three-dimensional (3D) reconstruction data, due to the soft tissue nature of the pneumatic system and presence of its surrounding soft tissue structures, some boundaries, and definitions of each extension remain ambiguous. We describe the comprehensive paratympanic sinus system in posthatched alligator using soft tissue enhanced CT data with 3D reconstructions. The data are compared to the available data to discuss the ontogenetic pattern in alligator. We introduce further divided entities of the pneumatic system based on their associated bony and soft tissue structures and epithelial membrane and clarify the pneumatic terminologies. We then re-visit the potential homology of

the paratympanic sinus in Archosauria. Epithelial boundaries of the ventral portion of the pneumatic system from the histological data suggest that the dual origin of the basioccipital diverticulum derived from the tympanic sinus and basicranial diverticulum medially. The presence of the epithelial boundary and pneumatic changes in ontogeny suggests that the middle ear may function differently in developmental stages. Lastly, a morphogenetic tree is constructed to help future work of comparative developmental studies of the paratympanic sinus system between crocodyles and birds.

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Dollman, K.N. and Choiniere, J.N. (2022). Palate evolution in early-branching crocodylomorphs: Implications for homology, systematics, and ecomorphology. *Anatomical Record* (Hoboken) (doi: 10.1002/ar.24993).

**Abstract:** Living crocodylomorphs have an ossified secondary palate with a posteriorly positioned choana that enables their semi-aquatic, predatory ecology. In contrast, the earliest branching members of Crocodylomorpha have an open palate with anteriorly positioned choanae. The evolution of an ossified secondary palate and a posteriorly positioned choana features strongly in hypotheses of broad-scale phylogenetic relationships within Crocodylomorpha. Renewed investigations into palatal morphology among extinct members of the clade show surprising variability in the anatomy of the palate, with at least one and potentially a second independent occurrence of “eusuchian-type” palate outside of Eusuchia. Understanding the trajectory of crocodylomorph palatal evolution is, therefore, a key to inferring crocodylomorph interrelationships and ecomorphology. To document early-branching crocodylomorph palatal anatomy, we developed an anatomical comparative dataset using computed tomography scan data and literature, comprising 12 early-branching crocodylomorph taxa. To understand discrete phenotypic changes in palatal structure, we compiled a phylogenetically broadly sampled character-taxon matrix from the existing literature, and revised its palatal characters, adding 10 new palatal characters. Our comparative anatomical investigations allow us to propose an adapted hypothesis for the closure of the palate and the posterior migration of the choana. Our phylogenetic findings corroborate previous research showing that non-crocodyliform crocodylomorphs (“sphenosuchians”) are paraphyletic, with the exclusion of the clade Hallopodidae. Non-mesoeucrocodylian crocodyliforms (“protosuchians”) are paraphyletic, but form three monophyletic clades: Notochampsidae, Shartegosuchidae, and Gobiosuchidae. We find a potential association between secondary palate development and dietary shifts, particularly with regard to hypothesized origins of herbivory.

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Poapolathep, S., Klangkaew, N., Wongwaipairoj, T., Chaiyabutr, N., Giorgi, M. and Poapolathep, A. (2022). Pharmacokinetics of danofloxacin in freshwater crocodyles (*Crocodylus siamensis*) after intramuscular injection. *Journal of Veterinary Pharmacology and Therapeutics* (doi: 10.1111/jvp.13072).

**Abstract:** The present study evaluated the pharmacokinetic profiles of danofloxacin (DNX) in freshwater crocodyles (*Crocodylus siamensis*), following single intramuscular (i.m.) administrations at two different dosages of 6 and 12 mg/kg body weight (b.w.). Blood samples were collected at assigned times up to 168 h. DNX in the harvested crocodile plasma was extracted using liquid-liquid extraction and analyzed using a validated high-performance liquid chromatography method equipped with fluorescence detection. The pharmacokinetic analysis was performed using a non-compartmental approach. DNX in plasma was quantifiable from 5 min to 168 h after i.m. administration at the two dosages in freshwater crocodyles. The area under the curve (AUC) and maximum concentration ( $C_{max}$ ) values increased in a dose-dependent fashion. Long elimination half-life (48.18 and 67.29 h) and low clearance (0.024 and 0.020 ml/g h) were obtained in the high- and low-dose groups, respectively. According to the pharmacokinetic-pharmacodynamic surrogate ( $AUC_{0-24h}/MIC > 125$ ), i.m. single administration of DNX at a

dosage of 6 mg/kg b.w. is predicted to have antibacterial success for disease caused by bacteria with  $MIC < 0.04 \mu\text{g/ml}$  in the freshwater crocodile, *C. siamensis*.

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Massonne, T., Augustin, F.J., Matzke, A.T., Weber, E. and Böhme, M. (2022). A new species of *Maomingosuchus* from the Eocene of the Na Duong Basin (northern Vietnam) sheds new light on the phylogenetic relationship of tomistomine crocodylians and their dispersal from Europe to Asia, *Journal of Systematic Palaeontology* (doi: 10.1080/14772019.2022.2054372).

**Abstract:** *Maomingosuchus acutirostris* sp. nov. is a new tomistomine crocodile from the middle-upper Eocene deposits (late Bartonian–Priabonian age, 39–35 Ma) of the Na Duong Basin in northern Vietnam. *M. acutirostris* can be differentiated from the type species *Maomingosuchus petrolicus* by having an acute anterior tip of the premaxilla. Both species differ from another *Maomingosuchus* from Krabi (Thailand) by differences in the surangular-dentary suture and maxillary alveoli. According to our phylogenetic results, *M. acutirostris* seems to be the sister species to the group *M. petrolicus* + Krabi-*Maomingosuchus*. The close relationship between those three tomistomines is supported in the present phylogenetic analysis by three synapomorphies. In our phylogenetic analysis, *Maomingosuchus* was retrieved in a basal position forming the sister group to *Paratomistoma* + *Gavialosuchus* + *Melitosaurus* + *Tomistoma*, including the extant *Tomistoma schlegelii*. This phylogeny indicates three different dispersal events of Tomistominae from Europe towards eastern Asia: 1) for the stem lineage of *Maomingosuchus*, no later than the late Eocene; 2) for the stem lineage of *Penghusuchus pani* + *Toyotamaphimeia machikanensis*, no later than the early-middle Miocene; and (3) for the stem lineage of *T. schlegelii*, during the Neogene.

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Habarugira, G., Moran, J., Harrison, J.J., Isberg, S.R., Hobson-Peters, J., Hall, R.A. and Bielefeldt-Ohmann, H. (2022). Evidence of infection with zoonotic mosquito-borne flaviviruses in saltwater crocodyles (*Crocodylus porosus*) in northern Australia. *Viruses* 14: 1106 (<https://doi.org/10.3390/v14051106>).

**Abstract:** The risk of flavivirus infections among the crocodylian species was not recognised until West Nile virus (WNV) was introduced into the Americas. The first outbreaks caused death and substantial economic losses in the alligator farming industry. Several other WNV disease episodes have been reported in crocodylians in other parts of the world, including Australia and Africa. Considering that WNV shares vectors with other flaviviruses, crocodylians are highly likely to also be exposed to flaviviruses other than WNV. A serological survey for flaviviral infections was conducted on saltwater crocodyles (*Crocodylus porosus*) at farms in the Northern Territory, Australia. Five hundred serum samples, collected from three crocodile farms, were screened using a pan-flavivirus-specific blocking ELISA. The screening revealed that 26% (n= 130/500) of the animals had antibodies to flaviviruses. Of these, 31.5% had neutralising antibodies to WNV<sub>KUN</sub> (Kunjin strain), while 1.5% had neutralising antibodies to another important flavivirus pathogen, Murray Valley encephalitis virus (MVEV). Of the other flaviviruses tested for, Fitzroy River virus (FRV) was the most frequent (58.5%) in which virus neutralising antibodies were detected. Our data indicate that farmed crocodyles in the Northern Territory are exposed to a range of potentially zoonotic flaviviruses, in addition to WNV<sub>KUN</sub>. While these flaviviruses do not cause any known diseases in crocodyles, there is a need to investigate whether infected saltwater crocodyles can develop a viremia to sustain the transmission cycle or farmed crocodylians can be used as sentinels to monitor the dynamics of arboviral infections in tropical areas.

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Lindblad, K.T., Moreno-Bernal, J.W., McKellar, R.C. and Velez, M.I. (2022). The Northern Crocodile: first report of *Borealosuchus* (Eusuchia: Crocodylia) from Saskatchewan’s Lower Ravenscrag

Formation (earliest Paleocene) with implications for biogeography. Canadian Journal of Earth Sciences (<https://doi.org/10.1139/cjes-2022-0010>).

**Abstract:** Two specimens of *Borealosuchus* collected from the lower facies of the Ravenscrag Formation (earliest Paleocene) in southern Saskatchewan are described. One largely complete individual featuring a partial skull, mandible, and postcrania can be unambiguously assigned to *B. griffithi*. The other specimen consisting of skull and partial postcranial fragments is referred to *B. sternbergii* based on diagnostic cranial features. These specimens confirm the earliest occurrence of this clade in the province of Saskatchewan and expand the known stratigraphic and geographic range of their respective species. The discovery of *B. griffithi* and *B. sternbergii* in proximity to each other within the same deposits suggest temporal and spatial range overlap in the Big Muddy area during the earliest Paleocene, hinting at possible niche partitioning or other ecological relationships between members of the same genus.

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Cowgill, T., Young Fls, M.T., Schwab, J.A., Walsh, S., Witmer, L.M., Herrera, Y., Dollman, K.N., Turner, A.H. and Brusatte, S.L. (2022). Cephalic salt gland evolution in Mesozoic pelagic crocodylomorphs. Zoological Journal of the Linnean Society (<https://doi.org/10.1093/zoolinnean/zlac027>).

**Abstract:** Secondarily marine tetrapod lineages have independently evolved osmoregulatory adaptations for life in salt water but inferring physiological changes in extinct marine tetrapods is difficult. The Mesozoic crocodylomorph clade Thalattosuchia is unique in having both direct evidence from natural endocasts and several proposed osteological correlates for salt exocrine glands. Here, we investigate salt gland evolution in thalattosuchians by creating endocranial reconstructions from CT scans of eight taxa (one basal thalattosuchian, one teleosauroid, two basal metriorhynchoids and four metriorhynchids) and four outgroups (three extant crocodylians and the basal crocodyliform *Protosuchus*) to identify salt gland osteological correlates. All metriorhynchoids show dorsolateral nasal cavity expansions corresponding to the location of nasal salt glands in natural casts, but smaller expansions in teleosauroids correspond more with the cartilaginous nasal capsule. The different sizes of these expansions suggest the following evolutionary sequence: (1) plesiomorphically small glands present in semi-aquatic teleosauroids draining through the nasal vestibule; (2) moderately sized glands in the basalmost metriorhynchoid *Pelagosaurus*; and (3) hypertrophied glands in the clade comprising *Eoneustes* and metriorhynchids, with a pre-orbital fenestra providing a novel exit for salt drainage. The large gland size inferred from basal metriorhynchoids indicates advanced osmoregulation occurred while metriorhynchoids were semi-aquatic. This pattern does not precisely fit into current models of physiological evolution in marine tetrapods and suggests a unique sequence of changes as thalattosuchians transitioned from land to sea.

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McVey, D. (2022). Human-Crocodile Conflict in Timor-Leste: Attack Characteristics and Management Implications. Undergraduate thesis, Lakehead University, Thunder Bay, Ontario, Canada.

**Abstract:** Timor-Leste is a relatively new developing nation, having gained its independence from Indonesia in 2002. The people of this country have a traditional belief system in which the saltwater crocodile, *Crocodylus porosus*, forms the basis of their creation myth and thus holds great cultural value. As the populations of both humans and crocodiles on the island grow, there have been increasing occurrences of human-crocodile conflict (HCC) throughout the country. Due to the unique situation in Timor-Leste, normal management practices for HCC are not directly applicable. As a result, this country requires specific considerations for dealing with this problem while remaining sensitive to cultural values. This paper aims to discuss characteristics of human-crocodile conflict in Timor-Leste and recommend strategies for management. Conflict

records from 2007-2021 were collected from the online database, CrocBITE, and attack characteristics and locations were analysed. Areas of concern due to high conflict rates are Tutuala and Lake Ira Lalaro of Lautem municipality, Suai of Cova Lima municipality, and Viqueque of Viqueque municipality. Attack hotspots followed core crocodile habitat distribution. Analysis of conflict characteristics determined that males (84%), subsistence fishers (73%) and youth below the age of 20 (43%) were the people most at risk of attack, with most conflicts (70%) resulting in a fatality. Age, activity, and water body had many cases in which these characteristics were unknown, with 32, 23, and 16 respectively. Most incidents occurred at ocean or beaches (32%), although incidents in rivers (23%) and lakes or ponds (23%) were common. Incidents peaked in the months of October to April, the warmer and wetter months, in accordance with crocodile activity levels. Crocodile size information was unavailable for most cases. Using information analysed here and existing literature, recommendations to help solve this problem were made, such as the use of traditional knowledge and education, establishment of economic incentives, genetic and migration pattern studies, and the integration of the traditional management system, Tara Bandu.

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Deeming, D.C. (2022). Inter-relationships among body mass, body dimensions, jaw musculature and bite force in reptiles. Journal of Zoology ([doi:10.1111/jzo.12981](https://doi.org/10.1111/jzo.12981)).

**Abstract:** Bite force is important in understanding how feeding biomechanics impacts the life-history of vertebrates. Bite force has been measured in many lizards and crocodylians but fewer turtles and snakes. Few comparative interspecific studies exist of the inter-relationships between body size, jaw musculature and bite force. This study collated data reported in the literature for bite force and mass of the jaw musculature in reptiles and explored the relationships between these variables and body mass and size. Two hypotheses were explored: (1) bite force and mass of the jaw musculature scale with body size irrespective of order (as a broad taxonomic grouping) when controlled for phylogeny, and (2) bite force and jaw musculature mass would be directly related and be unrelated to order. Phylogenetically controlled Bayesian analyses showed that in relation to body mass there were different relationships with bite force for testudines compared to saurians and crocodylians. For snout-vent length, squamates and crocodylians exhibited a single relationship, but for head length, all reptile orders exhibited different allometric patterns. Although there was a strong phylogenetic signal in all cases, indicating that there are clusters of closely related species for a measure of size, there was no effect of order on the relationships between measures of body size and mass of the jaw musculature. The relationship between bite force and jaw muscle mass was isometric and did not differ among reptile orders. Several ecological factors may correlate with head morphology and bite force in reptiles. Further studies could explore the evolutionary drivers that shape the relationship between head size, jaw musculature and bite force. Similarities for the relationships between bite force and body size in different reptilian orders suggests that this could be a model system to demonstrate fundamental biomechanical principles of how jaw muscles generate a bite force.

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Rio Rio, J.N. (2022). Study on the population status of the yacare (*Caiman yacare*) and the black caiman (*Melanosuchus niger*) in their natural distribution areas in Bolivia. Bioamazon 14: 19-29.

**Abstract:** Under the Regional Project for the Management, Monitoring and Control of Species of Wild Fauna and Flora Threatened by Trade (Bioamazon Project), the population status of the yacare (*Caiman yacare*) and the black caiman (*Melanosuchus niger*) was studied in their natural distribution areas, in Bolivia, during the dry seasons of years 2020 and 2021. This study was supervised by the Dirección General de Biodiversidad y Áreas Protegidas (Directorate of Biodiversity and Protected Areas DGBAP) of the Vice Ministry of the Environment, Biodiversity,

Climate Change and Forest Management and Development (VMABCCGDF). Population assessments were conducted, and yacare hunters and breeders were interviewed in different localities of La Paz and Santa Cruz. The information collected was analyzed and systematized with information provided by the DGBAP as results from assessments carried out in the preparation of alligator management plans to update the models for determining yacare harvest quotas at the national level. Likewise, priority sites were defined for the implementation of actions to strengthen the wild populations of black caiman.

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Mazzotti, F.J., Balaguera-Reina, S.A., Brandt, L.A., Briggs-González, V., Cherkiss, M., Farris, S. and Godahewa, A. (2022). Natural and anthropogenic factors influencing nesting ecology of the American crocodile in Florida, United States. *Frontiers in Ecology and Evolution* 10: 904576 (doi: 10.3389/fevo.2022.904576).

**Abstract:** Nesting ecology of American crocodiles (*Crocodylus acutus*) in Florida has been both positively and negatively influenced by anthropogenic and natural factors since the species was placed on the federally endangered species list in 1975. This includes a shift in nesting sites and an expansion of nesting to anthropogenic habitat. Using a 50-year record of monitoring data (1970-2020), we assessed factors influencing nesting ecology (number of nests, nest morphology, success rate, and habitat use) from a total of 3013 nests recorded across South Florida. We detected a change in nesting success rate, increasing from 61% in the 1970s to near 90% since 2010. Our hot spot analysis illustrates that nesting sites in northeastern Florida Bay and Flamingo/Cape Sable (Everglades National Park) were important for American crocodiles. Anthropogenic habitats, such as canals provided vital habitat nesting in areas such as Flamingo/Cape Sable (Everglades National Park), Turkey Point Power Plant, and Crocodile Lake National Wildlife Refuge for the current Florida population. Environmental parameters suspected to affect nesting success have shown an increasing trend over the past 50 years and minimum temperature and rainfall, during the summer season, are correlated with increased nesting success and temporal variation across South Florida. The adaptive capacity that American crocodiles exhibited in Florida gave the species advantages to face changes in climate and landscape over the last 50 years, however, it does not imply that the adaptive capacity of the species to face these changes (evolutionary potential) cannot reach a limit if changes continue. Here, we document *C. acutus* nesting ecology population responses to ecosystem restoration efforts in Florida; and further demonstrate the value of protecting and restoring habitat to support recovery of listed species.

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Ingram, D.J., Coad, L., Milner-Gulland, E.J., Parry, L., Wilkie, D., Bakarr, M.I., Benítez-López, A., Bennett, E.L., Bodmer, R., Cowlshaw, G., El Bizri, H.R., Eves, H.E., Fa, J.E., Golden, C.D., Iponga, D.M., Minh, N.V., Morcatty, T.Q., Mwinyihali, R., Nasi, R., Nijman, V., Ntiamoa-Baidu, Y., Pattiselanno, F., Peres, C.A., Rao, M., Robinson, J.G., Rowcliffe, J.M., Stafford, C., Supuma, M., Tarla, F.N., Van Vliet, N., Wieland, M. and Abernethy, K. (2022). Wild meat is still on the menu: Progress in wild meat research, policy, and practice from 2002 to 2020. *Annual Review of Environment and Resources* 46: 221-254.

**Abstract:** Several hundred species are hunted for wild meat in the tropics, supporting the diets, customs, and livelihoods of millions of people. However, unsustainable hunting is one of the most urgent threats to wildlife and ecosystems worldwide and has serious ramifications for people whose subsistence and income are tied to wild meat. Over the past 18 years, although research efforts have increased, scientific knowledge has largely not translated into action. One major barrier to progress has been insufficient monitoring and evaluation, meaning that the effectiveness of interventions cannot be ascertained. Emerging issues include the difficulty of designing regulatory frameworks that disentangle the different purposes of hunting, the large scale of urban consumption, and the implications

of wild meat consumption for human health. To address these intractable challenges, we propose eight new recommendations for research and action for sustainable wild meat use, which would support the achievement of the United Nations Sustainable Development Goals.

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Greer, S., Cramberg, M. and Young, B.A. (2022). Morphology of the distal tip of the spinal cord in *Alligator mississippiensis*. *The Anatomical Record* (<https://doi.org/10.1002/ar.25016>).

**Abstract:** Secondary neurulation is a common feature of vertebrate development which, in non-mammalian and non-anuran vertebrates, results in the formation of a caudal spinal cord. The present study was undertaken to describe the terminal end of the caudal spinal cord in a crocodylian, a group chosen for their unique status of a living tailed archosaur. The caudal spinal cord of *Alligator mississippiensis* terminates near the intervertebral joint between the 4th and 5th terminal vertebrae. Prior to this termination the dorsal root ganglia get proportionately larger, then stop before the termination of the spinal cord; and the grey matter of the spinal cord is lost producing an unusual morphology in which an ependymal-lined central canal is surrounded by only white matter which is not divided into a cauda equina. The inner layer of the meninges (the pia-arachnoid) courses over the distal end of the spinal cord and forms a ventral attachment, reminiscent of a very short filum terminal; there is no caudal cistern. The dura extends beyond the termination of the spinal cord, continuing for at least the length of the 4th terminal vertebra, forming a structure herein termed the distal meningeal sheath. During its course, the distal meningeal sheath surrounds a mass of mesothelial cells, then terminates as an attachment on the dorsal surface of the vertebra.

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Isberg, S. (2022). How many fathers? Study design implications when inferring multiple paternity in crocodylians. *Authorea Preprints*.

**Abstract:** Up to 10 males have been reported to sire clutches of crocodylian eggs but review of the underlying study designs raised questions of potential upward bias of inferred sire numbers. To test this premise, different scenarios were explored using a published dataset of 16 known single-sire saltwater crocodile pairs and their offspring which were originally confirmed using an 11 loci microsatellite panel in CERVUS. Varying the number of microsatellites, omitting one or both parental genotypes and using different parentage analysis techniques revealed that total allele number, rather than number of loci, determined inferred sire accuracy in two opposing ways. Using the single-locus minimum method and GERUD, which both require prior knowledge of family groupings (ie nests), fewer alleles (and loci) accurately inferred only one father. In contrast, CERVUS and COLONY required all 11 loci (65 alleles) and both parental genotypes to (a) assign correct family groups and (b) infer the correct sire number, except in one family where two sires were equally assigned based on their number of homozygous loci. When less genotype information was provided, CERVUS and COLONY inferred up to 6 and 7 sires, respectively. Consequently, crocodylian maternal genotypes should at least be obtained either directly (blood, tissue) or indirectly (eggshells, eDNA) in addition to a representative population sample of adult genotypes before embarking on multiple paternity determination. Running different scenarios using different analytical methods and reporting on the lowest number of inferred sires is encouraged remembering these sires are hypothetical until proven by true genotype.

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Nina Marn, N. and Kooijman, S.A.L.M. (2021). The comparative energetics of the turtles and crocodiles. *Ecology and Evolution* (doi: 10.1002/ece3.8996).

**Abstract:** The Add-my-Pet collection of data on energetics and Dynamic Energy Budget parameters currently contains 92 species

of turtles and 23 species of crocodiles. We discuss patterns of eco-physiological traits of turtles and crocodiles, as functions of parameter values, and compare them with other taxa. Turtles and crocodiles accurately match the general rule that the life-time cumulated neonate mass production equals ultimate weight. The weight at birth for reptiles scales with ultimate weight to the power 0.6. The scaling exponent is between that of amphibians and birds, while that for mammals is close to 1. We explain why this points to limitations imposed by embryonic respiration, the role of water stress and the accumulation of nitrogen waste during the embryo stage. Weight at puberty is proportional to ultimate weight, and is the largest for crocodiles, followed by that of turtles. These facts explain why the precociality coefficient,  $sbpH$  - approximated by the ratio of weight at birth and weight at puberty at abundant food - decreases with ultimate weight. It is the smallest for crocodiles because of their large size and is smaller for turtles than for lizards and snakes. The sea turtles have a smaller  $sbpH$  than the rest of the turtles, linked to their large size and small offspring size. We link their small weight and age at birth to reducing risks on the beach. The maximum reserve capacity in both turtles and crocodiles clearly decreases with the precociality coefficient. This relationship has not been found that clearly in other taxa, not even in other reptiles, with the exception of the chondrichthyans. Among reptiles, crocodiles and sea turtles have a relatively large assimilation rate and a large reserve capacity.

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Kidd-Weaver, A.D., Rainwater, T.R., Murphy, T.M. and Bodinof Jachowski, C.M. (2022). Evaluating the efficacy of capture as aversive conditioning for American alligators in human-dominated landscapes. *The Journal of Wildlife Management* 2022: e22259.

**Abstract:** As anthropogenic impacts on ecosystems increase, novel solutions are needed to mitigate increasing human-wildlife conflict. Aversive conditioning is one strategy that can reduce the risks of humans living alongside wildlife by modifying the behavior of animals through their experiences with humans. Although considered rare, American alligator (*Alligator mississippiensis*) attacks on humans most often occur in human-dominated landscapes and can be fatal. Our goal was to determine if capture and release protocols might serve as a form of aversive conditioning to reduce alligator tolerance of humans. Specifically, we compared the behavioral response of alligators to an approaching human for animals with 3 different levels of capture experience: alligators from a reference site where no captures occurred, alligators from a site where captures occurred that directly experienced capture and release, and alligators from the site where captures occurred that indirectly experienced capture and release (never captured but likely observed capture of others). We used a hurdle model and information-theoretic approach to evaluate support for 8 hypotheses regarding factors that influence alligator probability of flight in response to an approaching human and the flight initiation distance (FID) of alligators that did flee. Our hypotheses considered the effects of capture experience, exposure to non-capture (visual) surveys, alligator size, ambient temperature, and season. The best-supported models provided strong evidence that capture experience increased the probability of flight and, to a lesser extent, increased FID of alligators that did flee, but that the strength of the effect varied with alligator size or some correlate. Furthermore, the effect of capture may extend beyond animals with direct experience. Capture and release protocols can result in an aversive conditioning response in alligators, effectively reducing habituation to humans. Given the geographic limitations of our study, more work is necessary to determine whether the utility of aversive conditioning may be site-dependent, or similarly effective across a wider selection of developed landscapes.

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Bravo, G.G., Pol, D., Armella, M.A. and Gómez, K. (2022). The choanal anatomy of the *Sebecus icaeorhinus* Simpson, 1937 and the variation of the palatine shape in notosuchians (Crocodyliformes, Mesoeucrocodylia). *Journal of Paleontology* (doi: <https://doi.org/10.1017/jpa.2022.48>).

**Abstract:** Sebecidae is a clade of large carnivorous crocodyliforms that thrived in the Cenozoic and is the only lineage of the diverse and terrestrial group Notosuchia that survived the end-Cretaceous mass extinction event. *Sebecus icaeorhinus* is the best-known taxon from this clade, both in terms of its cranial and postcranial anatomy (known primarily from the holotype and specimen MPEF-PV 1776, respectively). Additional material represented by a partial skull (MMP 235) is the only specimen that has preserved a complete choanal region. We describe new information from this specimen based on an X-ray computed tomography and identify through comparisons with other taxa a large degree of variability in the palatal anatomy within Sebecidae, in particular in the shape and extension of the palatine (the bone that defines the anterior position and shape of the secondary choana). We quantify variation in the shape of the palatine bone of sebecids through a 2D morphogeometric analysis within the context of notosuchian crocodyliforms. Although traditional accounts of palatal evolution in crocodyliforms linked variation of this structure to the adaptation to the aquatic environment, our analysis allows recognition of eight palatine morphotypes among terrestrial crocodyliforms with very distinct paleoecological traits, including carnivorous, omnivorous, and possibly herbivorous taxa. Furthermore, we show that sebecids had a higher morphological disparity in the choanal region than other terrestrial groups of Notosuchia, underscoring the importance of this region for comparative, morphofunctional, and phylogenetic studies.

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Kisling, V.N., Jr. (Ed.) (2022). *Zoo and Aquarium History - Ancient Animal Collections to Conservation centers*, 2nd Edition. CRC Press: Boca Raton.

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Khadka, B.B., Bashyal, A. and Griffith, P. (2022). Post-release growth of captive-reared Gharial *Gavialis gangeticus* (Gmelin, 1789)(Reptilia: Crocodylia: Gavialidae) in Chitwan National Park, Nepal. *Journal of Threatened Taxa*, 14(5): 21002-21009.

**Abstract:** Supplementation of wild populations of the Critically Endangered Gharial *Gavialis gangeticus* with individuals reared in captivity is a widely used conservation management tool in Nepal and India, although its efficacy is uncertain. Measuring post-release growth in Gharial can provide valuable information on acclimation of captive-reared Gharial to the wild and provide growth rates to inform population recovery models. We studied post-release growth of Gharial reared in the Gharial Conservation Breeding Centre, Nepal, following their release into the Chitwan National Park. We used recapture data from known individuals to determine growth and change of mass for 26 Gharial recaptured 0.5-10 years after release. We found that Gharial recaptured two or more years post-release had increased in mass and length despite being over six years old at release, however there was a triangular relationship between time since release and growth: some Gharial had grown very slowly, whilst others had grown much faster. All Gharial recaptured less than two years since release had lost mass and had negligible growth in total length. This data show that there is considerable variation in post-release growth rates, which will lead to some individuals being very old before they reach a potentially mature size class, with unknown implications for reproduction. This variation is important for predicting or modelling recovery in populations where the release of Gharial from captivity is a management tool. Our results also suggest the two years after release are an acclimation phase - when Gharial lose mass and do not grow - which should be considered by release strategies in order to give Gharial the best chance of survival after release.

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Brum, P.H.R., Goncalves, S.R.A., Strussmann, C. and Teixeira, A.L. (2022). A global assessment of research on urban ecology of reptiles: patterns, gaps and future directions. *Animal Conservation* (doi:10.1111/acv.12799).

**Abstract:** Global urban expansion has multiple impacts on biodiversity and ecosystem functioning. Still, urban centres may play an important role in the conservation of reptiles, an undersampled, megadiverse and unevenly distributed group especially vulnerable to anthropogenic impacts. However, major gaps in research on the urban ecology of reptiles and species responses to urbanisation persist, which may limit our capacity to guide suitable conservation policies. We conducted a global systematic literature review to evaluate biogeographic, taxonomic and ecological research biases in the urban ecology of reptiles and ultimately to detect major gaps and steer future sampling efforts. Our database comprised 278 articles dealing with biological responses to urbanisation of 493 species across 45 countries, comprising 658 cases between a given species and specific biological response. Research on the urban ecology of reptiles was geographically and taxonomically biased. Developed countries within temperate regions were better sampled, whereas developing tropical and megadiverse countries were mostly undersampled or neglected. Among reptile orders, Testudines and Crocodylia were proportionally more studied than Squamata. Across lower groups within Squamata, lizards were present in most studies and were the biological model most commonly used. Studies evaluating biological responses associated with landscape-level processes, behaviour and/or population dynamics were prevalent, whereas conservation, human-reptile conflicts and wildlife management were the least considered topics. Our results show that research on urban ecology of reptiles is unevenly distributed across regions and lineages. Overcoming these major gaps is an important step towards the improvement of the conservation of reptiles worldwide under the upcoming biodiversity loss scenario. Beyond spreading sampling efforts across undersampled countries, taxa and research topics to meet conservation objectives, we recommend more multidisciplinary approaches to evaluate and compare the actual performance of reptiles in urban environments and to achieve the equilibrium between human well-being and species conservation.

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Slape, R.L. and Milic, N.L. (2022). Histological determination of skin thickness in farmed Australian *Crocodylus porosus*. Acta Histochemistry 124(6) (doi: 10.1016/j.acthis.2022.151914).

**Abstract:** This descriptive study examined the variation in ventral *Crocodylus porosus* (saltwater crocodile) belly skin. The study is the first to determine both intra and inter variation of *C. porosus* skin, epidermis and dermis thickness across the ventral belly region. Standardised ventral scales from across the belly region of a Hatchling (<12months), Yearling (1-2 years) and Grow Out (>2 years) animals were examined using histological measurements for the stratum (s.) corneum, a combined measure for the remainder of the epidermis; the s. granulosum, s. spinosum and s. basale, and the dermis. This study determined that there was a thinning across all layers of the belly skin, from the head to the cloaca, and a decrease in thickness scales in lateral scales compared to midline scales. Variation within a scale was found predominately in the s. corneum and can be related to the change in keratin type from beta- to alpha- in the hinge (inter-scalar) region and the integumentary sensory organs. Future studies should utilise a larger sample size and consider less invasive imaging techniques.

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Brochu, C.A., de Celis, A., Adams, A.J., Drumheller, S.K., Nestler, J.H., Benefit, B.R., Grossman, A., Kirera, F., Lehmann, T., Liutkus-Pierce, C., Manthi, F.K., McCrossin, M.L., McNulty, K.P. and Nyaboke Juma, R. (2022). Giant dwarf crocodiles from the Miocene of Kenya and crocodylid faunal dynamics in the late Cenozoic of East Africa. Anatomical Record (Hoboken) (doi: 10.1002/ar.25005).

**Abstract:** We describe two new osteolaemine crocodylids from the Early and early Middle Miocene of Kenya: *Kinyang mabokoensis* tax. nov. (Maboko, 15 Ma) and *Kinyang tchernovi* tax. nov. (Karungu and Loperot, 18 Ma). Additional material referable to *Kinyang* is known from Chianda and Moruorot. The skull was broad and dorsoventrally deep, and the genus can be diagnosed based on the

combined presence of a partial overbite, a subdivided fossa for the lateral collateral ligament on the surangular, and a maxilla with no more than 13 alveoli. Phylogenetic analyses based on morphological and combined morphological and molecular data support a referral of *Kinyang* to Osteolaeminae, and morphological data alone put the new taxon at the base of Euthecodontini. Some *Kinyang* maxillae preserve blind pits on the medial caviconchal recess wall. *Kinyang* co-occurs with the osteolaemine *Brochuchus* at some localities, and together, they reinforce the phylogenetic disparity between early Neogene osteolaemine-dominated faunas and faunas dominated by crocodylins beginning in the Late Miocene in the Kenya Rift. The causes of this turnover remain unclear, though changes in prevailing vegetation resulting from tectonic and climatic drivers may provide a partial explanation.

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Wilhite, R. and Nevarez, J. (2022). A review of venipuncture sites in *Alligator mississippiensis* with anatomical description of a novel venipuncture site. Anatomical Record (Hoboken) (doi: 10.1002/ar.24995).

**Abstract:** Here we describe and illustrate the sites of venipuncture in the alligator using CT reconstructions, cross-sectional anatomy, and traditional dissection. We also describe the clinical approach for each venipuncture site and describe a novel site for venipuncture in crocodylians, the lateral occipital sinus. Based on the authors' experience, the lateral occipital sinuses offer the safest, simplest, and most consistent access for venipuncture in the alligator. Future studies should examine other crocodylian species to confirm the presence of the lateral occipital sinuses.

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Holliday, C.M., Sellers, K.C., Lessner, E.J., Middleton, K.M., Cranor, C., Verhulst, C.D., Lautenschlager, S., Bader, K., Brown, M.A. and Colbert, M.W. (2022). New frontiers in imaging, anatomy, and mechanics of crocodylian jaw muscles. Anatomical Record (Hoboken) (doi: 10.1002/ar.25011).

**Abstract:** New imaging and biomechanical approaches have heralded a renaissance in our understanding of crocodylian anatomy. Here, we review a series of approaches in the preparation, imaging, and functional analysis of the jaw muscles of crocodylians. Iodine-contrast microCT approaches are enabling new insights into the anatomy of muscles, nerves, and other soft tissues of embryonic as well as adult specimens of alligators. These imaging data and other muscle modeling methods offer increased accuracy of muscle sizes and attachments without destructive methods like dissection. 3D modeling approaches and imaging data together now enable us to see and reconstruct 3D muscle architecture which then allows us to estimate 3D muscle resultants, but also measurements of pennation in ways not seen before. These methods have already revealed new information on the ontogeny, diversity, and function of jaw muscles and the heads of alligators and other crocodylians. Such approaches will lead to enhanced and accurate analyses of form, function, and evolution of crocodylians, their fossil ancestors and vertebrates in general.

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Ruebenstahl, A.A., Klein, M.D., Yi, H., Xu, X. and Clark, J.M. (2022). Anatomy and relationships of the early diverging Crocodylomorphs *Junggarsuchus sloani* and *Dibothrosuchus elaphros*. Anatomical Record (Hoboken) (doi: 10.1002/ar.24949).

**Abstract:** The holotype of *Junggarsuchus sloani*, from the Shishugou Formation (early Late Jurassic) of Xinjiang, China, consists of a nearly complete skull and the anterior half of an articulated skeleton, including the pectoral girdles, nearly complete forelimbs, vertebral column, and ribs. Here, we describe its anatomy and compare it to other early diverging crocodylomorphs, based in part on CT scans of its skull and that of *Dibothrosuchus elaphros* from the Early Jurassic of China. *Junggarsuchus* shares many features with a cursorial assemblage of crocodylomorphs, informally known

as “sphenosuchians,” whose relationships are poorly understood. However, it also displays several derived crocodyliform features that are not found among most “sphenosuchians.” Our phylogenetic analysis corroborates the hypothesis that *Junggarsuchus* is closer to Crocodyliformes, including living crocodylians, than are *Dibothrosuchus* and *Sphenosuchus*, but not as close to crocodyliforms as *Almadasuchus* and *Macelognathus*, and that the “Sphenosuchia” are a paraphyletic assemblage. *D. elaphros* and *Sphenosuchus acutus* are hypothesized to be more closely related to Crocodyliformes than are the remaining non-crocodyliform crocodylomorphs, which form several smaller groups but are largely unresolved.

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Blob, R.W., Espinoza, I.Z.G. and Iijima, M. (2022). Anatomy informs geology: Hydrodynamic dispersal of alligator bones, with implications for taphonomic interpretations of fossil deposits of crocodylians, dinosaurs, and other morphologically novel taxa. *Anatomical Record* (Hoboken) (doi: [10.1002/ar.25003](https://doi.org/10.1002/ar.25003)).

**Abstract:** Distinctive anatomical features of bones can influence not only how these structures perform in living animals but also the tendency of elements to be transported by flowing water after death. Such transport can be critical in the concentration of fossils from animals that live near freshwater habitats, providing important context for interpreting the composition of paleocommunities. Measurements of the tendency of flowing water to disperse skeletal elements have been collected for diverse taxa, including mammals, turtles, and birds. However, these extant models may not be entirely appropriate for many morphologically distinct extinct lineages, such as non-avian dinosaurs. To expand the range of models available for evaluating the influence of hydrodynamic transport on the assembly of fossil deposits, we used a flow tank to measure the water speeds that disperse bones from a subadult American alligator (*Alligator mississippiensis*), with the skull and mandible tested in multiple starting orientations. Alligator bones are sorted into three main dispersal groups: early (vertebrae, most girdle elements), intermediate (ribs, most limb bones), and late (pubis, femur), with the skull and mandible varying between intermediate and late depending on orientation. Late dispersing elements tended to be heavy or very flat. These results can refine interpretations of the taphonomic context for deposits of fossil crocodylians and morphologically similar taxa (eg chorisoderes, phytosaurs) and provide an additional comparative model for deposits of non-avian dinosaurs. Moreover, variation in hydrodynamic sorting across lineages highlights how distinctive anatomical features can influence the concentration of fossils, shaping understanding of assemblage composition and paleofaunal evolution.

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Rehorek, S.J., Elsey, R.M. and Smith, T.V. (2022). Ontogeny of the nasolacrimal apparatus and nasal sensory systems of the American alligator (*Alligator mississippiensis*). *Journal of Morphology* (doi: [10.1002/jmor.21489](https://doi.org/10.1002/jmor.21489)).

**Abstract:** The nasolacrimal apparatus (NLA) is a feature common to many sauropsid amniotes. It consists of an orbital Harderian gland (HG) whose secretions drain into the nasal cavity, in the vicinity of the vomeronasal organ (VNO), an accessory olfactory organ derived from the olfactory epithelium, and a connecting nasolacrimal duct (NLD). Though not all features are present in all posthatchling sauropsids (ie no VNO in crocodylomorphs), it is not clear if this system either never existed or failed to develop during the embryonic stages. The purpose of this study is to histologically describe the ontogeny of the NLA and the main olfactory organ in *Alligator mississippiensis*. *Alligator* specimens, from embryonic stage 9 to hatchling, were serially histologically sectioned, stained, photographed, and segmented into different tissues using Adobe Photoshop and then reconstructed using Amira for 3D analysis and quantitative nasal epithelial distribution. Though there was no evidence of a VNO, the rest of the NLA was present. The development of the NLA could be subdivided into four phases: (1) inception of NLD, (2) establishment of orbitonasal connections of

NLD, (3) bone development, and (4) nasal cavity growth. Glands mature during this last phase and the nasal region rapidly grows, rotates, and is displaced anteriorly. The gradual proportional increase in nonolfactory epithelial distribution during ontogeny is consistent with the literature. *Alligator* embryonic nasal and NLD growth differs from that of mammals and squamates. The NLD is connected to the anterior third of the nasal region during its initial attachment, but as anterior nasal growth exceeds posterior growth, it is gradually displaced into the posterior third of the nasal region by hatching. It is unknown whether this is a derived archosaur condition or just another example of the morphological variation seen within sauropsid amniotes.

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Alvarez-Gonzalez, C.A., Martínez-Cárdenas, L., Torres-Aguilar, J.L., Espinosa-Chaurand, D., León-Fernández, A.E., Galaviz-Villa, I., Hernández-Vázquez, F., Castillo-Vargasmachuca, S.G. and Álvarez-González, C.A. (2022). Effect of different stocking densities in juveniles of American crocodile (*Crocodylus acutus*, Crocodylia, Crocodylidae) in captivity. *Agro Productividad* (<https://doi.org/10.32854/agrop.v14i6.2252>).

**Abstract:** Objective: To evaluate the effect of different stocking densities: 12 (D12), 18 (D18) and 24 (D24) individuals m<sup>-2</sup> (ind m<sup>-2</sup>) on growth (weight and length) and survival in juvenile river crocodiles (*Crocodylus acutus*). Design/methodology/approach: The crocodiles were cultured in each treatment by triplicate for 43 d in nine plastic tanks and fed a diet based on a mix of beef liver, fish and commercial dog food. Results: At the end of the experiment, there were not significant differences among treatments in the growth variables, recording a low increment in weight and total length (38.99 ± 8.96 g and 4.19 ± 1.36 cm; mean ± SD) in all densities as well as overall survival of 62.02 ± 7.67% (mean ± SD). The stocking density of 24 ind m<sup>-2</sup> was significantly higher in biomass production by m<sup>2</sup> for the stocking densities of 18 and 12 individuals (p<0.05). Limitations on study/implications: The development of culture techniques is a tool to assess the potential of this ecologically important species for its conservation and eventual commercialization. Findings/conclusions: It can be recommended a stocking density of 24 ind m<sup>-2</sup> (D24) to optimize the use of space and infrastructure profitability.

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Greco, R. (2022). Revitalizing Conservation and Management of the American Crocodile (*Crocodylus acutus*) in the Dominican Republic. MSc thesis, University of North Florida, USA.

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Agustin, H., Hidayat, D.R., Supriadi, D. and Aunillah, R. (2022). The media verification of hoaxes about human-crocodile conflicts. *Jurnale Komunikasi* 7(1): 101-111.

**Abstract:** The human-crocodile conflict frequently happens in Indonesia. Based on the data from <http://www.crocodile-attack.info/>, it is claimed that Indonesia is a country with the most cases of crocodile attacks. Mostly the attacks involved the saltwater crocodile (*Crocodylus porosus*). On the other hand, this conflict is worsened by the spread of inaccurate information among communities. From October 2019 to October 2021, there were 12 false stories about crocodile attacks. These hoaxes were distributed on social media, causing fear to those who consumed the information. It is crucial to be investigated, especially from the perspective of environmental journalism. This study describes how mainstream media outlets tried to clarify the hoaxes. The results show many materials contained by information disorder, which need to be clarified by the media to ensure clarity and truth for the public. This study finds that most mainstream media still have their conscience to protect the public from false information. It was done by practicing curation journalism that includes the discipline of verification. In conclusion, the media and information sources need to have a good comprehension of crocodile behavior. The research also catches the need for environmental journalism training for media practitioners

in Indonesia. Thus, the media will be able to offer the best solution for reducing the attack while at the same time giving adequate education for the public to live in harmony with Indonesian flora and fauna.

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Audije-Gil, J., Canillas, M., Barroso-Barcenilla, F., Berrocal-Casero, M., Del Campo, A., Martin, A.G., Molera, J., Vallcorba, O., Rodriguez, M.A. and Cambra-Moo, O. (2022). Going deeper into modern and fossil crocodylian tooth microanatomy: What can be inferred of Palaeoenvironment and taphonomy from histochemical analyses? *Rivista Italiana di Paleontologia e Stratigrafia* (Research in Paleontology and Stratigraphy) 128(2): 539-557.

**Abstract:** Teeth provide information about the evolutionary pathway of an organism, its biology and habitat. This is the case even of fossilized teeth, since they have perdurable biomineralized structures, as biological apatite. The material that has been selected for this study comprises teeth from modern crocodylian individuals and extinct Cretaceous crocodylomorphs from Lo Hueco site. Microanatomy, histochemistry and crystallographic nature of enamel, dentine and cementum have been characterized by Polarized Light Microscopy, SEM-EDS, Confocal Raman Spectroscopy and SR- $\mu$ XRD. A focus has been made on dentine lamination. In the fossil sample short-period incremental lines show alternate presence of dentinal tubules that has not been described previously either in living or fossil archosaur. This could be related to influence of environmental circadian rhythms in the abundance, size and/or activity of cells depositing dentine in the day-night cycle. Regarding histochemical and crystallographic compositions, the major and mostly unique phase is HA, but in the case of fossil teeth, a secondary phase identified as hematite appears locally between discontinuities of the material. Incremental lines would not be related to variation in chemical composition and furthermore do not present different HA crystallographic nature (different directions of HA or different crystallite sizes) either. Only small intensity oscillations are observed in the fossil sample by SR- $\mu$ XRD which are compatible with the alternating abundance of dentinal tubules. Crystallinity differences between modern and fossil material, as crystallite size and presence of CO<sub>3</sub><sup>2-</sup> groups could be explained by postdepositional processes.

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Moore, L.A., Finger Jr., J.W., Haskins, D.L., Elsey, R.M., Castleberry, S.B., Glenn, T.C., Jagoe, C.H. and Brisbin Jr., I.L. (2022). Tissue distribution of mercury in the bodies of wild American alligators (*Alligator mississippiensis*) from a coastal marsh in Louisiana (USA). *Archives of Environmental Contamination and Toxicology* (<https://doi.org/10.1007/s00244-022-00938-3>).

**Abstract:** Total mercury (THg) concentrations were measured in wild alligators inhabiting a coastal marsh in southern Louisiana, to determine the tissue distribution of THg among various body organs and tissue compartments. Concentrations of THg in claws and dermal tail scutes were compared to those in blood, brain, gonad, heart, kidney, liver, and skeletal muscle to determine if the former tissues, commonly available by non-lethal sampling, could be used as measures of body burdens in various internal organs. Mercury was found in all body organs and tissue compartments. However, overall, THg concentrations measured in alligators were below the FDA action level for fish consumption and were comparable to previous data reported from southwestern Louisiana. Our results suggest consumption of meat from alligators found in this region may be of little public health concern. However, the extended period of time between sampling (in this study) and the present-day highlight the need for continuous, additional, and more recent sampling to ensure consumer safety. Total mercury concentrations were highest in the kidney (3.18±0.69 mg/kg dw) and liver (3.12±0.76 mg/kg dw). THg levels in non-lethal samples (blood, claws, and dermal tail scutes) were positively correlated with all tissue THg concentrations (blood: R<sup>2</sup>=0.513-0.988; claw: R<sup>2</sup>=0.347-0.637, scutes: R<sup>2</sup>=0.333-0.649). Because THg concentrations from blood, claws, and scutes were correlated with those of the internal organs, non-lethal

sampling methods may be a viable method of estimating levels of THg in other body tissues.

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Hale, M., Koal, T., Pham, T.H., Bowden, J.A. and Parrott, B.B. (2022). Transcriptional networks underlying a primary ovarian insufficiency disorder in alligators naturally exposed to EDCs. Available at SSRN: <https://ssrn.com/abstract=4129767> or <http://dx.doi.org/10.2139/ssrn.4129767>.

**Abstract:** Interactions between the endocrine system and environmental contaminants are responsible for impairing reproductive development and function. Despite the taxonomic diversity of affected species and attendant complexity inherent to natural systems, the underlying signaling pathways and cellular consequences are mostly studied in lab models. To resolve the genetic and endocrine pathways that mediate affected ovarian function in organisms exposed to endocrine disrupting contaminants in their natural environments, we assessed broad-scale transcriptional and steroidogenic responses to exogenous gonadotropin stimulation in juvenile alligators (*Alligator mississippiensis*) originating from a lake with well-documented pollution (Lake Apopka, FL) and a nearby reference site (Lake Woodruff, FL). We found that individuals from Lake Apopka are characterized by hyperandrogenism and display hyper-sensitive transcriptional responses to gonadotropin stimulation when compared to individuals from Lake Woodruff. Site-specific transcriptomic divergence appears to be driven by wholly distinct subsets of transcriptional regulators, indicating alterations to fundamental genetic pathways governing ovarian function. Consistent with broad-scale transcriptional differences, ovaries of Lake Apopka alligators displayed impediments to folliculogenesis, with larger germinal beds and decreased numbers of late-stage follicles. After resolving the ovarian transcriptome into clusters of co-expressed genes, most site-associated modules were correlated to ovarian follicle phenotypes across individuals. However, expression of two site-specific clusters were independent of ovarian cellular architecture and are hypothesized to represent alterations to cell-autonomous transcriptional programs. Collectively, our findings provide high resolution mapping of transcriptional patterns to specific reproductive function and advance our mechanistic understanding regarding impaired reproductive health in an established model of environmental endocrine disruption.

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Ferguson, A.L. (2022). Investigating Nests and Eggs of Modern and Fossil Amniotes. PhD thesis, Idaho State University, Idaho, USA.

**Abstract:** Nests and eggs represent the beginning of life for many vertebrates. Determining the nesting strategies of extant amniotes is crucial in elucidating the evolution and diversification of reproductive traits as nesting materials are poorly preserved in the fossil record. Avian and chelonian nests are particularly rare compared to non-avian dinosaurs. The goal of this dissertation is to investigate and describe the sedimentology, taphonomy, and ecology of two fossil nesting localities and examine modern eggshell porosity via micro-CT images. I characterized two nesting localities, one from the Late Cretaceous Kaiparowits Formation in Grand Staircase-Escalante National Monument outside of Escalante, Utah, the second in the Eocene Bridger Formation east of Lyman, Wyoming, in terms of sedimentology and stratigraphy and taphonomy. Eggshell from the Kaiparowits Formation is identified as testudine and unique characteristics of the shell unit height-to-width ratio, egg size, eggshell thickness, and ornamentation warrant the naming of a new ootaxa, *Testudoolithus tuberi*. The distribution of eggshell is interpreted as resulting from nest predation. The Bridger Formation eggshell material is similar since the distribution and preservation of half eggs is interpreted as being caused by predation. Both of the nesting localities are imbedded in greenish-gray mudstones overlying and under lithic sandstones, suggesting flood-plain deposition. The avian eggshell is named a new ootaxon as well, (*Doolithus bridgerensis*), from the number of observable ultrastructural layers. Micro-CT images of modern rigid-shelled

amniotes, including birds, crocodylians, a tortoise, and a gecko, reveals a complex network of internal pores that do not connect to the external surface of the eggshell. The functional pores tend to be cylindrical to trumpet-shaped in birds and pear-shaped in the tortoise, but are bowl-shaped in the gecko, conical in the crocodylian genera *Crocodylus* and *Osteolaemus*, and globular in *Melanosuchus niger*. Eggs in open and closed nesting strategies have generally similar functional eggshell porosity ranges of 0.1-0.8% sample volume. However, covered nesters generally have higher total porosities of 2.9-16.1%. The internal porosity arises from the interstitial spaces between mineralized egg units. The functional value of the internal porosity is yet unknown, but may improve properties of shell insulation and retention of water vapor.

Sukkheewan, R., Poapolathep, A., Giorgi, M., Klangkaew, N., Phaochoosak, N., Wongwaipairoj, T., Udomkusonsri, P., Chaiyabutr, N. and Poapolathep, S. (2022). Pharmacokinetic characteristics of azithromycin in freshwater crocodiles (*Crocodylus siamensis*) after intramuscular administration at three different dosages. *Journal of Veterinary Pharmacology and Therapeutics* (doi: 10.1111/jvp.13080).

**Abstract:** The study evaluated the pharmacokinetic features of azithromycin (AZM) in 15 freshwater crocodiles (*Crocodylus siamensis*) in Thailand. The crocodiles were administered a single intramuscular (i.m.) injection of AZM at three different dosages of 2.5, 5 and 10 mg/kg body weight (b.w.). Blood samples were collected at pre-assigned times up to 168 h. The plasma concentrations of AZM were measured using a validated liquid chromatography-tandem mass spectrometry method. The plasma concentration of AZM were quantifiable for up to 168 h after i.m. administration at the three different dosages. A non-compartmental model was used to fit the plasma concentration of AZM versus the time curve for each crocodile. The elimination half-life values of AZM were 33.70, 38.11 and 34.80 h following i.m. injection after dosages of 2.5, 5 and 10 mg/kg b.w., respectively. There were no significant differences among groups. The results indicated that the overall rate of elimination of AZM in freshwater crocodiles was relatively slow. The maximum concentration and area under the curve from zero to the last values of AZM increased in a dose-dependent fashion. The average binding percentage of AZM to plasma protein was 48.66%. Based on the pharmacokinetic data, the susceptibility break-point and the surrogate PK-PD index (T>MIC), the intramuscular administration of AZM at a dose of 10 mg/kg b.w. might be appropriate for the treatment of susceptible bacterial infections (MIC<4 µg/ml) in freshwater crocodiles.

Bell, P.R., Hendrickx, C., Pittman, M. and Kaye, T.G. (2022). Oldest preserved umbilical scar reveals dinosaurs had 'belly buttons'. *BMC Biology* 20(1):132 (doi: 10.1186/s12915-022-01329-9).

**Abstract:** In egg-laying amniotes, the developing embryo is tethered to a number of the extraembryonic membranes including the yolk sac and allantois that deliver oxygen and nutrients and remove metabolic waste products throughout embryonic development. Prior to, or soon after hatching, these membranes detach from the animal leaving a temporary or permanent umbilical scar (umbilicus) equivalent to the navel or 'belly button' in some placental mammals, including humans. Although ubiquitous in modern mammals and reptiles (including birds), at least early in their ontogeny, the umbilicus has not been identified in any pre-Cenozoic amniote. We report the oldest preserved umbilicus in a fossil amniote from a ~130-million-year-old early-branching ceratopsian dinosaur, *Psittacosaurus*. Under laser-stimulated fluorescence (LSF), the umbilicus is revealed as an elongate midline structure delimited by a row of paired scales on the abdomen. The relatively late ontogenetic stage (close to sexual maturity) estimated for the individual indicates that the umbilicus was probably retained throughout life. Unlike most extant reptiles and birds that lose this scar within days to weeks after hatching, the umbilicus of *Psittacosaurus* persisted at least until sexual maturity,

similar to some lizards and crocodylians with which it shares the closest morphological resemblance. This discovery is the oldest record of an amniote umbilicus and the first in a non-avian dinosaur. However, given the variability of this structure in extant reptilian analogues, a persistent umbilical scar may not have been present in all non-avian dinosaurs.

Gunawardana, B.H.S.M. (2022). Diversity and abundance of mangrove species and anthropogenic threats to them in Bentota River estuary, Galle, Sri Lanka. Pp. 26 in *Proceedings of the 26th International Forestry and Environment Symposium 2022*.

**Abstract:** Mangroves are intertidal plants with a remarkable diversity that have adapted to grow in saline and water-logged soil. The Bentota River Estuary has a dominant riverine mangrove forest that is located in one of the highly populated districts in Sri Lanka thus currently facing many anthropogenic stresses. Bentota River is located in Galle District which separates the Southern and Western provinces. However, it has not been recently studied for its mangrove diversity and abundance. Therefore, a transect survey was carried out to investigate the diversity and abundance of mangrove species together with the possible anthropogenic threats to the river and mangrove forest. A total of 43 randomly selected transects along the river were demarcated. A 200 m gap was maintained between each transect and transects were sub-divided into 5x5 m quadrats. The transect length depended on the width of the forest from the river bank to the inland. Both true mangroves and mangrove associates were taken into account. Shannon Diversity Index (H'), Simpson Index (D), and Shannon Evenness (E) were calculated to analyze the diversity and relative abundances. A total number of 4536 mangrove individuals and mangrove associates were enumerated during the survey. A total of 18 species belonging to 15 families and 15 genera were recorded during the study. Eight (8) true mangrove species and ten (10) mangrove associates were identified from the area. *Bruguiera sexangula* (43.3%), *Rhizophora apiculata* (5.2%), *Nypa fruticans* (4.1%), *Sonneratia caseolaris* (3.5%), *Excoecaria agallocha* (1.9%), *Bruguiera gymnorhiza* (0.3%), *Excoecaria indica* (0.2%), and *Heritiera littoralis* (0.2%) are the true mangrove species recorded during the study. *Acrostichum aureum* (19.3%), *Cerbera manghas* (15.9%), *Acanthus ilicifolius* (2%), *Barringtonia racemosa* (1.3%), and *Pandanus kaida* (1.2%) are the common mangrove associates. The calculated Shannon Diversity Index shows value as 1.76, Simpson Index as 0.74, and Evenness as 0.61. Rhizophoraceae, Lythraceae, Apocynaceae, Arecaceae, and Pteridaceae are the most common families recorded from the area. It is clear that Bentota River represents a unique mangrove diversity. Several anthropogenic threats were recorded viz., illegal construction, cutting down mangrove trees, clearing for cultivation, and illegal hunting of Saltwater Crocodile (*Crocodylus porosus*). Hence, adequate conservation measures and law enforcement should be in place to halt these illegal activities. Moreover, this mangrove habitat provides a favorable refuge for endangered Southern Purple Faced Leaf Monkey (*Semnopithecus vetulus vetulus*), and Saltwater Crocodile. Therefore, protecting this sensitive ecosystem should be of the outermost importance.

Kurucz, N., McMahon, J.L., Warchot, A., Hewitson, G., Barcelon, J., Moore, F., Moran, J., Harrison, J.J., Colmant, A.M.G., Staunton, K.M., Ritchie, S.A., Townsend, M., Meyer Steiger, D., Hall, R.A., Isberg, S.R. and Hall-Mendelin, S. (2022). Nucleic acid Preservation card surveillance is effective for monitoring arbovirus transmission on crocodile farms and provides a one health benefit to Northern Australia. *Viruses* 14 (https://doi.org/10.3390/v14061342).

**Abstract:** The Kunjin strain of West Nile virus (WNVKUN) is a mosquito-transmitted flavivirus that can infect farmed saltwater crocodiles in Australia and cause skin lesions that devalue the hides of harvested animals. We implemented a surveillance system using honey-baited nucleic acid preservation cards to monitor WNV<sub>KUN</sub> and another endemic flavivirus pathogen, Murray Valley

encephalitis virus (MVEV), on crocodile farms in northern Australia. The traps were set between February 2018 and July 2020 on three crocodile farms in Darwin (Northern Territory) and one in Cairns (North Queensland) at fortnightly intervals with reduced trapping during the winter months. WNV<sub>KUN</sub> RNA was detected on all three crocodile farms near Darwin, predominantly between March and May of each year. Two of the NT crocodile farms also yielded the detection of MVEV viral RNA sporadically spread between April and November in 2018 and 2020. In contrast, no viral RNA was detected on crocodile farms in Cairns during the entire trapping period. The detection of WNV<sub>KUN</sub> and MVEV transmission by FTA<sup>TM</sup> cards on farms in the Northern Territory generally correlated with the detection of their transmission to sentinel chicken flocks in nearby localities around Darwin as part of a separate public health surveillance program. While no isolates of WNV<sub>KUN</sub> or MVEV were obtained from mosquitoes collected on Darwin crocodile farms immediately following the FTA<sup>TM</sup> card detections, we did isolate another flavivirus, Kokobera virus (KOKV), from *Culex annulirostris* mosquitoes. Our studies support the use of the FTA<sup>TM</sup> card system as a sensitive and accurate method to monitor the transmission of WNV<sub>KUN</sub> and other arboviruses on crocodile farms to enable the timely implementation of mosquito control measures. Our detection of MVEV transmission and isolation of KOKV from mosquitoes also warrants further investigation of their potential role in causing diseases in crocodiles and highlights a “One Health” issue concerning arbovirus transmission to crocodile farm workers. In this context, the introduction of FTA<sup>TM</sup> cards onto crocodile farms appears to provide an additional surveillance tool to detect arbovirus transmission in the Darwin region, allowing for a more timely intervention of vector control by relevant authorities.

Ngernjan, M., Ontawong, A., Lailerd, N., Mengamphan, K., Sarapirom, S. and Amornlerdpison, D. (2022). Crocodile oil modulates inflammation and immune responses in LPS-stimulated RAW 264.7 macrophages. *Molecules* 27(12) (doi: 10.3390/molecules27123784).

**Abstract:** Crocodile oil (CO) is generated from the fatty tissues of crocodiles as a by-product of commercial aquaculture. CO is extensively applied in the treatment of illnesses including asthma, emphysema, skin ulcers, and cancer, as well as wound healing. Whether CO has anti-inflammatory properties and encourages an immune response remains uncertain. The impact of CO on inflammatory conditions in lipopolysaccharide (LPS)-stimulated RAW 264.7 cells and the mechanisms behind it were examined in this work. Cells were treated with 0.125-2% CO dissolved in 0.5% propylene glycol with or without LPS. The production and expression of inflammatory cytokines and mediators were also examined in this research. CO reduced the synthesis and gene expression of interleukin-6 (IL-6). Consistently, CO inhibited the expression and synthesis of inflammatory markers including cyclooxygenase-2 (COX-2), prostaglandin E2 (PGE2), nitric oxide (NO), and nuclear factor kappa B (NF- $\kappa$ B). Furthermore, CO reduced the effects of DNA damage. CO also increased the cell-cycle regulators, cyclins D2 and E2, which improved the immunological response. CO might thus be produced as a nutraceutical supplement to help avoid inflammatory diseases.

Te Velde, K., Peeters, E., Verdegem, M. and Beijer, J. (2022). Aquaculture carrying capacity of Nile tilapia *Oreochromis niloticus* and Nile crocodile *Crocodylus niloticus* in Lake Kariba, Zambia and Zimbabwe. *Aquaculture Environment Interactions* 14: 113-125.

**Abstract:** Increased aquaculture production can improve food and nutrition security and economic growth in developing countries, but comes with environmental risks. In recent years, aquaculture has increased tremendously in Lake Kariba, which is located on the border between Zambia and Zimbabwe. We calculated the carrying capacity of aquaculture production in Lake Kariba using the Beveridge P balance model with data for lake-wide total-P

concentrations, river flows and data from aquaculture farms and feed producers in the Lake Kariba area. The maximum permissible P load for aquaculture farms in Lake Kariba is  $1.2 \times 10^6$  kg P yr<sup>-1</sup>. Average loss of P to the environment in Lake Kariba through farming is 13.92 kg P t<sup>-1</sup> for Nile tilapia *Oreochromis niloticus* and 92.5 kg P t<sup>-1</sup> for Nile crocodile *Crocodylus niloticus*. Consequently, sustainable aquaculture carrying capacity in Lake Kariba is 86,900 t yr<sup>-1</sup> for *O. niloticus* and 13,000 t yr<sup>-1</sup> for *C. niloticus*. We expect aquaculture production in Lake Kariba to account for 71% of the total allowable aquaculture P load by 2028. The total-P concentration is expected to increase to 28.5 mg m<sup>-3</sup> by 2028 due to growth in aquaculture, and its development should be carefully monitored. In future, we recommend that our predictions should be compared to observed changes in order to validate the model. We also illustrate that companies can greatly improve the carrying capacity of a system by improving the feed conversion ratio, the efficiency of nutrient uptake and the processing of mortalities.

Kuzmin, I.T. (2022). Crocodyliform remains from the Upper Cretaceous of Central Asia - evidence for one of the oldest Crocodylia? *Cretaceous Research* (<https://doi.org/10.1016/j.cretres.2022.105266>).

**Abstract:** Late Cretaceous is key time interval for the understanding of origins and diversification of the crown-group Crocodylia and its extant lineages - Alligatoroidea, Crocodyloidea, and Gavialoidea. Yet, the fossil record of crocodylians in the beginning of the Late Cretaceous is scarce, obscuring the early evolutionary history of the clade. Here I review all known material of long-snouted crocodyliforms from the Upper Cretaceous (Cenomanian-Santonian) of Central Asia. Based on the extensive sampling in the Dzharakuduk locality (Bissekty Formation) and the distinctive anatomy of individual elements, they are referred to the enigmatic taxon *Zholsuchus procerus* Nessov et Cherepanov, 1989. Comparable specimens from other localities are tentatively attributed to *Zholsuchus* sp. or cf. *Zholsuchus* sp. *Zholsuchus* is herein confirmed as a valid taxon for the first time since its establishment. Based on extensive morphological comparison, I hypothesize that it is potentially a crown-group crocodylian that may be related to Gavialoidea. However, additional material is required to test taxonomic and phylogenetic hypotheses proposed in this study. *Zholsuchus* is allegedly a medium-sized crocodylian, attaining minimal total body lengths of 2 metres and perhaps ranging up to 2.5-3 m. Remains associated with this taxon are rare but consistently recovered in the lower Cenomanian-Santonian deposits of Uzbekistan and Kazakhstan. *Zholsuchus*, along with *Portugalosuchus* from Cenomanian of Portugal, may be the oldest presently known crocodylians, which expands the fossil record of the crown-group back into the beginning of the Late Cretaceous and suggests the much earlier origins of the clade than it has been usually acknowledged.

Romero-Calderón, A.G., Álvarez-Legorreta, T., Rendón von Osten, J., González-Jáuregui, M. and Cedeño-Vázquez, J.R. (2022). Stress responses in captive *Crocodylus moreletii* associated with metal exposure. *Environmental Pollution* (doi: 10.1016/j.envpol.2022.119685).

**Abstract:** Environmental pollution by metals has repercussions on wildlife health. It is known that some metals can have an influence on the neuroendocrine stress response, and at the same time, metals have pro-oxidant effects that can overwhelm the antioxidant system and cause oxidative stress. This study evaluates the association of metals with neuroendocrine stress activity and biomarkers of oxidative stress in 42 captive female Morelet's crocodiles (*Crocodylus moreletii*). We measured five metals of ecotoxicological importance (Hg, Cd, Pb, Cu and Zn), and three biomarkers of the oxidative stress response in the liver: glutathione (GSH) and glutathione disulfide (GSSG) as markers for antioxidant system and thiobarbituric acid reactive substances (TBARS) for oxidative

damage. We also measured one biomarker of the neuroendocrine response to stress: corticosterone (B) in blood plasma. The mean  $\pm$  SD concentrations of metals in the liver expressed in  $\mu\text{g/g}$  (dw) were: Cd:  $0.004 \pm 0.003$ , Hg:  $0.014 \pm 0.019$ , Cu:  $0.017 \pm 0.013$ , Zn:  $0.043 \pm 0.035$ , Pb:  $0.16 \pm 0.256$ . The mean  $\pm$  SD of GSH was  $0.42 \pm 0.35$  nmol/mg protein, the mean  $\pm$  SD of GSSG was  $0.24 \pm 0.20$  nmol/mg protein, the mean  $\pm$  SD concentrations of TBARS were  $0.36 \pm 0.21$  nmol/mg protein, and the mean  $\pm$  SD of B was  $393.57 \pm 405.14$  pg/mL. Hg presented a significant negative relationship with corticosterone. Cd had a negative relationship with both GSH and GSSG; meanwhile, Zn showed a negative relationship with TBARS levels, could be a protective element against hepatic oxidative damage. Finally, B had negative relationship with oxidative damage. The connection found between Hg and the neuroendocrine stress response, as well as the correlations of Cd and Zn with oxidative damage and antioxidant activity should be studied further, given their toxicological importance and implications for the conservation of *C. moreletii* and other crocodylians.

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Legendre, L.J., Choi, S. and Clarke, J.A. (2022). The diverse terminology of reptile eggshell microstructure and its effect on phylogenetic comparative analyses. *Journal of Anatomy* (doi: 10.1111/joa.13723).

**Abstract:** Reptile eggshell ensures water and gas exchange during incubation and plays a key role in reproductive success. The diversity of reptilian incubation and life history strategies has led to many clade-specific structural adaptations of their eggshell, which have been studied in extant taxa (ie birds, crocodylians, turtles and lepidosaurs). Most studies on non-avian eggshells were performed over 30 years ago and categorized reptile eggshells into two main types: “hard” and “soft” - sometimes with a third intermediate category, “semi-rigid.” In recent years, however, debate over the evolution of eggshell structure of major reptile clades has revealed how definitions of hard and soft eggshells influence inferred deep-time evolutionary patterns. Here, we review the diversity of extant and fossil eggshell with a focus on major reptile clades, and the criteria that have been used to define hard, soft, and semi-rigid eggshells. We show that all scoring approaches that retain these categories discretize continuous quantitative traits (eg eggshell thickness) and do not consider independent variation of other functionally important microstructural traits (eg degree of calcification, shell unit inner structure). We demonstrate the effect of three published approaches to discretizing eggshell type into hard, semi-rigid, and soft on ancestral state reconstructions using 200+ species representing all major extant and extinct reptile clades. These approaches result in different ancestral states for all major clades including Archosauria and Dinosauria, despite a difference in scoring for only 1-4% of the sample. Proposed scenarios of reptile eggshell evolution are highly conditioned by sampling, tree calibration, and lack of congruence between definitions of eggshell type. We conclude that the traditional “soft/hard/semi-rigid” classification of reptilian eggshells should be abandoned and provide guidelines for future descriptions focusing on specific functionally relevant characteristics (eg inner structures of shell units, pores, and membrane elements), analyses of these traits in a phylogenetic context, and sampling of previously undescribed taxa, including fossil eggs.

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Knight, A., Phillips, C. and Sparks, P. (Eds.) (2022). *Routledge Handbook of Animal Welfare*. Routledge: London.

**Abstract:** This handbook presents a much-needed and comprehensive exploration of the rapidly growing fields of animal welfare and law. In recent years there has been increasing attention paid to our complex, multifaceted relationships with other animals, and in particular, the depth and breadth of various societal uses of animals. This has led to a reconsideration of their moral and social status, which has sometimes challenged the interests of those who use animals. In such a contested domain, sound evidence and reasoning become particularly important. Through firm commitment to such

principles, this book explores the biological foundations for the moral consideration of animals and for evolving conceptualisations of animal welfare. It reviews in detail the welfare concerns associated with numerous forms of animal use. The inclusion of key recent developments such as climate change, pandemics, and antimicrobial resistance, ensures this text is among the most current in its field. The ethical implications of the various uses of animals by society are considered, and chapters provide important recommendations for reforms of practice, law, or policy. The status of animal law internationally, and in major world regions, is reviewed. Finally, the book considers human behavioural change and strategies for improving stakeholder communication and education. The handbook is essential reading for students and scholars of animal welfare, animal law and animal ethics everywhere, and for policy-makers and other professionals working in the animal welfare sector.

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Halaçlar, K., Rummy, P., Liu, J., Hunt, A., Do, T.V., Nguyen, M.T. and Deng, T. (2022). Exceptionally well-preserved crocodylian coprolites from the Late Eocene of Northern Vietnam (Na Duong Formation) and their coproecological implications. *Research Square* (<https://doi.org/10.21203/rs.3.rs-1790005/v1>).

**Abstract:** Reconstructing the paleoenvironment of Na Duong Basin by using coproecology is significant in understanding the intensive prey-predator relationships, the tropic relationship and the ecosystem evolution within the paleo-locality. A total of 55 measurable coprolites (IVPP V 27941/1 till IVPP V27491/55) and numerous coprolite fragments from Na Duong fossil site were examined in this study. The putative coprolites were assigned to a crocodylian producer. Ichnosystematic studies further erected a new ichnogenus and species, which is *Crococopros naiduongensis* ichnogen. et ichnosp. nov. for IVPP V27491/46, based on a set of derived characters. Apart from quantitative analyses, a multi-disciplinary approach was also utilised for biogeochemistry analyses. The study has provided a rare and unique snapshot into the past where we believe an ancient river or lake-like environment has most likely existed in Na Duong Basin and was dominated by crocodylian fauna. We deemed that the Na Duong food chain was indeed ideal and healthy for the survival of the crocodylian species during that particular period of time with sufficient food sources. In addition, the study showed tangible evidence of the richness of ichnofauna, fauna, flora, the suitable climate, and paleoenvironment that supported Na Duong Basin as a fossil-Lagerstätte of Southeast Asia.

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Kruis, F., Wallwork, M., Spain, M. and Rosenblatt, A.E. (2022). American alligator (*Alligator mississippiensis*) weight gain in captivity and implications for captive reptile body condition. *Zoo Biology* (doi: 10.1002/zoo.21721).

**Abstract:** The body condition of an animal is an indicator of health status and is dependent upon many factors, some of which can vary between wild and captive settings. Despite this, there have not been many studies on how captivity affects body condition relative to wild animal populations. This study explores the body condition of captive and wild American alligators (*Alligator mississippiensis*) because reptiles are frequently overlooked in studies of captive animal health and because alligators are well-represented in captivity. We collected body condition data from 209 captive alligators and 935 wild alligators throughout Florida and southeastern Georgia and compared the relationships between body condition and body length for each group. We found that captive alligators exhibited significantly higher body condition values as they aged, and that this result was driven by the difference between captive and wild males. Body condition values for captive juveniles did not differ from wild juveniles, but they differed when comparing adults. Our results suggest that factors such as diet and movement rates play major roles in determining alligator body condition and that body condition may be an important metric for monitoring captive alligator health, especially for older adult males.

Abellán, N., Baquedano, E. and Domínguez-Rodrigo, M. (2022). High-accuracy in the classification of butchery cut marks and crocodile tooth marks using machine learning methods and computer vision algorithms. *Geobios* (<https://doi.org/10.1016/j.geobios.2022.07.001>).

**Abstract:** Some researchers using traditional taphonomic criteria (groove shape and presence/absence of microstriations) have cast some doubts about the potential equifinality presented by crocodile tooth marks and stone tool butchery cut marks. Other researchers have argued that multivariate methods can efficiently separate both types of marks. Differentiating both taphonomic agents is crucial for determining the earliest evidence of carcass processing by hominins. Here, we use an updated machine learning approach (discarding artificially bootstrapping the original imbalanced samples) to show that microscopic features shaped as categorical variables, corresponding to intrinsic properties of mark structure, can accurately discriminate both types of bone modifications. We also implement new deep-learning methods that objectively achieve the highest accuracy in differentiating cut marks from crocodile tooth scores (99% of testing sets). The present study shows that there are precise ways of differentiating both taphonomic agents, and this invites taphonomists to apply them to controversial paleontological and archaeological specimens.

Gamboa-Delgado, J., Ponce-Campos, P., Pérez-Martínez, S.G., Pacheco-Vega, J.M. and Villarreal-Cavazos, D. (2022). Stable isotope measurements as analytical tools for the traceability of crocodile-derived products. *Animal Biodiversity and Conservation* 45(2): 217-24.

**Abstract:** Stable isotope measurements as analytical tools for the traceability of crocodile-derived products. In this preliminary study we examined the application of dual stable isotope analysis ( $\delta^{13}\text{C}$  and  $\delta^{15}\text{N}$ ) to identify the origin of skins and meat derived from wild and farmed crocodiles. Traceability protocols can benefit from analytical techniques that are able to distinguish farmed or wild organisms. Scutes and muscle samples were obtained from wild and farmed crocodiles *Crocodylus acutus* (n= 14) and *C. moreletii* (n= 9). Isotopic values in scutes differed significantly between wild and farmed organisms, this difference being higher for  $\delta^{15}\text{N}$  than for  $\delta^{13}\text{C}$  values. When both isotopic values were integrated using a discriminant analysis, we observed a significant categorization. The isotopic values of muscle samples were very similar to those measured in scutes from the same individuals. In addition, two specimens of *C. acutus* were kept on a constant diet for 97 days to obtain reference isotopic values and tissues were compared. We also estimated the isotopic discrimination factors between tissues and the supplied diet.

Puy, L. (2022). Aquatic fauna and aquaculture. Pp. 343-354 in *Water and Life in Tonle Sap Lake*, ed. by C. Yoshimura, R. Khanal and U. Sovannara. Springer: Singapore.

**Abstract:** The inundated area of the seasonally flooded habitats in Tonle Sap Lake varies from 1314 km<sup>2</sup> to 5343 km<sup>2</sup>. The water level varies from 2 to >5 m at the beginning of the rainy season (July-August) and reaches 8-9 m in October. In this large floodplain, fishes are strongly adapted to the seasonal flood-pulse dynamics and habitat types. The Tonle Sap Authority's inventory in 2010-2019 listed 167 fish species, belonging to 12 orders, 35 families, and 94 genera. More than 70% of the total fish sampled were found to belong to the order of Cypriniformes, Siluriformes, and Perciformes. The relationship between species diversity and heterogeneous habitats provides useful information for better understanding of their life cycles in the Tonle Sap Lake (TSL) ecosystem, which is critically important for the conservation of their diversity and productivity. Aquaculture by cage is mostly practiced in the flooding villages. Around 6520 cages and 210 ponds have been designed for fish farming in and directly around TSL, including 650 cages for crocodile farms.

Soria-Ortiz, G.J., García-Navarrete, P.G., Ochoa-Ochoa, L.M. and Rincón-Gutiérrez, A. (2022). Potential distribution of hybrids between *Crocodylus acutus* and *Crocodylus moreletii* on the Mexican Pacific coast outside the natural hybridisation zone. *Herpetological Journal* (<https://doi.org/10.33256/32.3.93101>).

**Abstract:** In Mexico, *Crocodylus acutus* is widely distributed along the Pacific coast, while *C. moreletii* occurs on the Gulf of Mexico. Both species converge in the Yucatán Peninsula where natural hybridisation is reported, and later it was also reported in the Gulf of Mexico. Unfortunately, due to translocations and stochastic events, currently there are hybrids of both species on the coast of Oaxaca and Guerrero. In this study, we evaluated the potential colonisation areas of the hybrids on the Pacific coast through ecological niche analyses. The results indicate that the hybrid crocodiles and the parent species share preferences in at least three climatic variables: average temperature range, isothermality, and minimum temperature of the coldest month. Furthermore, it was found that the climatic niche of the hybrids is more similar to that of the *C. moreletii* leaving reminiscent areas for *C. moreletii* in Nuevo León, San Luis Potosí and small areas far from the coast in Veracruz, coinciding with what was previously reported by molecular analysis. On the other hand, the climatic niche of the hybrid crocodiles is also sufficiently similar to that of *C. acutus*, having the possibility to colonise the Pacific coast extensively, leaving reminiscent small areas for *C. acutus* on the northern coast of Sinaloa, southern of Sonora, central coast of Oaxaca and small inland areas of the Pacific coast.

Preuschoft, H. (2022). What have the extremities of “lower tetrapods” in common? And why? Pp. 167-199 in *Understanding Body Shapes of Animals*. Springer: Cham.

**Abstract:** Most primitive tetrapods possess a rather slender trunk, neck of short or medium length and a long tail (see Chap. 4), all this in combination with sprawling limbs. Modern forms belong to lissamphibians (salamanders), archosaurs (crocodiles and alligators) and lepidosaurs (lizards, eg iguanids, monitors). The similarity and the old age of this body shape and the respective locomotor modes have also been emphasised by Reilly *et al.* (2006). Recently, Usherwood and Davies (2017) have collected empirical data on duty factors and footfall sequences in many species of amphibians, reptilians and mammals. Our own observations are concentrated on monitors and several other lizards (Christian 1995), as well as crocodiles (Preuschoft *et al.* 2007 (mit Schulte)).

Brachaniec, T., Środek, D., Surmik, D., Niedźwiedzki, R., Georgalis, G.L., Płachno, B.J., Duda, P., Lukeneder, A., Gorzelak, P. and Salamon, M.A. (2022). Comparative actualistic study hints at origins of alleged Miocene coprolites of Poland. *PeerJ* 10: e13652.

**Abstract:** Excrement-shaped ferruginous masses have been recovered from the Miocene of Turów mine in south-western Poland. These siderite masses have been the subject of much controversy, having been interpreted either as being coprolites, cololithes or pseudofossils created by mechanical deformation of plastic sediment. Here we present the results of mineralogical, geochemical, petrographic and microtomographical analyses. Our data indicate that these masses consist of siderite and iron oxide rather than phosphate, and rarely contain recognizable food residues, which may suggest abiotic origins of these structures. On the other hand, evidence in support of a fecal origin include: (i) the presence of two distinct morphotypes differing in size and shape, (ii) the presence of rare hair-like structures or coalified inclusions and (iii) the presence of rare fine striations on the surface. Importantly, comparative actualistic study of recent vertebrate feces shows overall resemblance of the first morphotype (sausage-shaped with rare coalified debris) to excrements of testudinoid turtles (Testudinoidea), whose shell fragment was found in the investigated locality. The second morphotype (rounded to oval-shaped with hair-like structures), in turn, is similar to the feces of some snakes

(Serpentes), the remains of which were noted in the Miocene of the neighborhood areas. Other potential producers (such as lizards and crocodiles) and even abiotic origins cannot be fully excluded but are less likely.

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Aiyer, A., Rangers, B., Bell, T., Shine, R., Somaweera, R., Bruny, M. and Ward-Fear, G. (2022). Taking the bait: Developing a bait delivery system to target free-ranging crocodiles and varanid lizards with a novel conservation strategy. *Ecology & Evolution* 12(6): e8933.

**Abstract:** In tropical Australia, conditioned taste aversion (CTA) can buffer vulnerable native predators from the invasion of a toxic prey species (cane toads, *Rhinella marina*). Thus, we need to develop methods to deploy aversion-inducing baits in the field, in ways that maximize uptake by vulnerable species (but not other taxa). We constructed and field-tested baiting devices, in situ with wild animals. Apparatus were set next to waterbodies and baited concurrently at multiple locations (over water, water's edge, and on the bank). Baits were checked and replaced twice daily during the trial; remote cameras recorded visitation by native predators. Bait longevity was compared at sun-exposed and shaded locations over 12 h. The strength required to remove baits from apparatus was measured in varanids and crocodiles. The device promoted high rates of bait uptake by freshwater crocodiles (47% baits consumed), varanid lizards (19% baits consumed), and non-target taxa (34% baits consumed). Targeting specific predators can be achieved by manipulating bait location and time of deployment, as well as the force required to dislodge the bait. Crocodiles were best targeted with over-water baits, whereas varanid lizards preferred baits located at the edges of waterbodies. When testing bait longevity in ambient conditions, during the daytime baits desiccated fully within 12 h, and faster in the sun than in the shade. Based on studies using captive animals, the "pulling force" strength of reptilian predators scaled with body size and was greater in crocodiles than in varanid lizards. We present the first conservation baiting protocol designed specifically for reptiles. Our results demonstrate the feasibility of widespread and taxon-specific deployment of aversion-inducing baits to buffer the impacts of invasive cane toads, and our methods are applicable (with modification) to other research and management programs globally.

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Young, B.A. and Cramberg, M.J. (2022). Treadmill locomotion in the American alligator (*Alligator mississippiensis*) produces dynamic changes in intracranial cerebrospinal fluid pressure. *Scientific Reports* 12(1): 11826.

**Abstract:** To examine the influence of movement on cerebrospinal fluid (CSF) dynamics, intracranial subdural pressure recordings were taken from sub-adult alligators (*Alligator mississippiensis*) locomoting on a treadmill. Pressure recordings documenting the cardiac, ventilatory, and barostatic influences on the CSF were in good agreement with previous studies. During locomotion the CSF exhibits sinusoidal patterns of pressure change that spanned a mean amplitude of 56 mm Hg, some 16 × the amplitude of the cardiac-linked pulsations. These sinusoidal CSF pulsations were closely linked to the locomotor kinematics, particularly the lateral oscillations of the alligator's head. Data recorded from the freely moving alligators suggest that fluid inertia, body cavity pressures, and likely other factors all influence the CSF pressure. The clear

relationship between movement and CSF pressure described in this study suggests that the paucity of studies examining human CSF dynamics during movement should be addressed.

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Chowdhury, A.H. (2022). Impacts of industrialization and infrastructure developments on the flora, fauna and ecosystems of the Sundarbans and surrounding areas. *African Journal of Biological Sciences* 4(3) (doi: 10.33472/AFJBS.4.3.2022.22-40).

**Abstract:** The impacts of rapid industrialization in the periphery of the Sundarbans on the flora and fauna (tiger, deer, crocodile, dolphin, fishes, etc.) and ecosystem of the Sundarbans, surrounding areas and on the other components like river banks erosion, livelihoods of the people, etc. of the Sundarbans and surrounding areas were studied to develop a guideline for future conservation and restoration. The study area is 20 km inside and outside (Periphery) of the Sundarbans under Mongla and Rampal *upazilas* of Bagerhat district, Bangladesh. Fortnight sampling was carried out and air, water, soil and biological samples were studied in the field and laboratory. The recorded data indicate that the present condition of Sundarbans and its surrounding area has reflected a sign of threatened environment. The Sundarbans has lost both floral and faunal diversity by the years. Tigers are disappeared, fishes lost their habitat, trees are affected with unknown diseases, other faunal diversity are also disappeared, erosion is concentrated along the Pashur River, people are being helpless and migrated their occupation. The industries have also brought the curse for natural environment of this area by discharging waste, gases, hot water recklessly into river and surrounding water bodies. As a result the world largest mangrove forest - Sundarbans may can lose its recognition as world heritage site.

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Field, E.K., Hartzheim, A., Terry, J., Dawson, G., Haydt, N. and Neuman-Lee, L.A. (2022). Reptilian innate immunology and ecoimmunology: What do we know and where are we going? *Integrative Comparative Biology* (doi: 10.1093/icb/icac116).

**Abstract:** Reptiles, the only ectothermic amniotes, employ a wide variety of physiological adaptations to adjust to their environments but remain vastly understudied in the field of immunology and ecoimmunology in comparison to other vertebrate taxa. To address this knowledge gap, we assessed the current state of research on reptilian innate immunology by conducting an extensive literature search of peer-reviewed articles published across the four orders of Reptilia (Crocodylia, Testudines, Squamata, Rhynchocephalia). Using our compiled dataset, we investigated common techniques, characterization of immune components, differences in findings and type of research among the four orders, and immune responses to ecological and life-history variables. We found that there are differences in the types of questions asked and approaches used for each of these reptilian orders. The different conceptual frameworks applied to each group has led to a lack of a unified understanding of reptilian immunological strategies, which, in turn, have resulted in large conceptual gaps in the field of ecoimmunology as a whole. To apply ecoimmunological concepts and techniques most effectively to reptiles, we must combine traditional immunological studies with ecoimmunological studies to continue to identify, characterize, and describe the reptilian immune components and responses. This review highlights the advances and gaps that remain to help identify targeted and cohesive approaches for future research in reptilian ecoimmunological studies.

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