CROCODILE SPECIALIST GROUP NEWSLETTER

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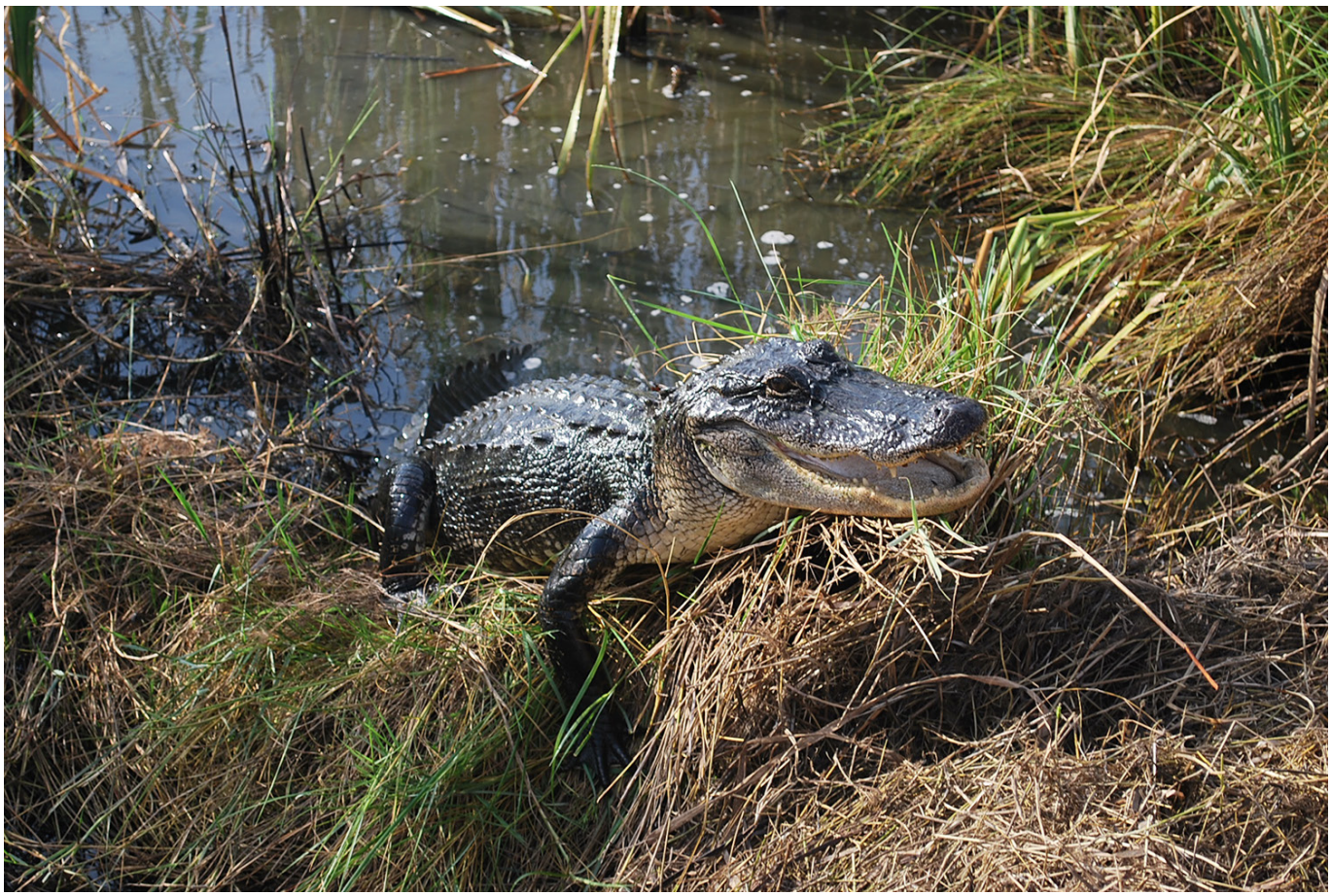

IUCN • Species Survival Commission

CROCODILE

SPECIALIST

GROUP

NEWSLETTER

VOLUME 41 Number 1
JANUARY 2022 - MARCH 2022

IUCN - Species Survival Commission

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COVER PHOTOGRAPH: Female American alligator (*Alligator mississippiensis*) defending her nest on Rockefeller Wildlife Refuge, Grand Chenier, Louisiana, USA. Louisiana Department of Wildlife and Fisheries biologists were collecting eggs for research studies when this nest was checked on 4 June 2012, the first collecting trip of the year in an unusually early nesting season. Photograph: Ruth Elsey.

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CSG Newsletter

The CSG Newsletter is produced and distributed by the Crocodile Specialist Group of the Species Survival Commission (SSC) of the IUCN (International Union for Conservation of Nature).

The CSG Newsletter provides information on the conservation, status, news and current events concerning crocodilians, and on the activities of the CSG. It is available as a free electronic, downloadable copy from "http://www.iucncsg.org/pages/Publications.html".

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We thank all patrons who have donated to the CSG and its conservation program over many years, and especially to donors in 2020-2021 (listed below).

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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, the Chair Grahame Webb, following consultation with SSC Chair Jon Paul Rodriguez, advised the CSG membership that he was stepping down from most duties as Chair in order to assist his recovery from a minor accident. Alejandro Larriera and Charlie Manolis were appointed as interim joint Chairs for the next 6 months (to end of July 2022). We are happy to report that Professor Webb is recovering well, and is well on the way to a full recovery.

On 2 July 2022, our Cuban friend and colleague Toby Ramos had to undergo surgery to amputate one of his legs. For weeks Toby had suffered from insufficient blood supply to his leg, a condition that was exacerbated by his diabetes, and which forced him to be hospitalized. Doctors initially attempted to save his leg by amputating two toes, but that did not stop the spread of gangrene, and they were forced to amputate the leg. The operation was successful, and we wish Toby a speedy recovery.

It is however with a heavy heart that we report the passing of Jerome Caraguel in March 2022. Jerome was very well known in the global crocodilian farming industry, and was also a long-time member of the CSG Steering Committee. A detailed obituary will be presented in the next issue of the Newsletter.

On a brighter note, the CSG celebrated the 50th anniversary of its first Working Meeting (1971) with the production of a video, which is available on YouTube (see pages 4-6). We thank everyone who was involved in the production of this video.

The 26th CSG Working Meeting is going ahead, in Chetumal, Mexico, on 3-8 July 2022 (see page 4). We encourage people to participate in the meeting, but also appreciate that some may still have difficulties with travel associated with the COVID-19 pandemic. For this reason, organisors are planning to have some sessions of the Working Meeting available virtually for people who are unable to attend.

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

Situation Analysis on the Role and Risks of Wildlife in the Emergence of Human Infectious Diseases

This recent publication from the IUCN was initially motivated by the COVID-19 pandemic and its alleged link to wildlife trade. However, a deeper understanding was required, so as to address the largely unsubstantiated narratives being made about wild animals and risks of disease.

This analysis is an evidence-based examination of the relationship between wildlife and zoonosis, wildlife and emerging human pathogens and associated diseases, their origins, drivers, and risk factors. The evidence of human diseases coming from wildlife is compared to diseases emerging from domestic animals and humans, to provide context and proportions of the relative risk.

The report concludes that the intial reaction of calling for a ban on all wildlife trade, was not supported by scientific evidence, and would not have had a substantial impact on preventing future epidemics or that averting any of the current risks.

Citation: Kock., R. and Caceres-Escobar, H. (2022). Situation Analysis on the Roles and Risks of Wildlife in the Emergence of Human Infectious Diseases. IUCN: Gland, Switzerland (https://doi.org/10.2305/IUCN.CH.2022.01.en).

Freshwater Species at Risk

In 2010, to address a global freshwater biodiversity crisis, the Species Survival Commission (SSC) of the International Union for Conservation of Nature (IUCN) created the Freshwater Conservation Committee (FCC; IUCN 2022). The main activities of the FCC (IUCN 2022) are:

- coordination of freshwater species conservation activities through the SSC, to highlight emerging patterns and to ensure that increasing attention is given to issues concerning freshwater biodiversity conservation;
- to make recommendations to the SSC based on the work of the FCC;
- to ensure freshwater species conservation issues are aligned within the SSC and the wider IUCN;
- to assist the SSC by providing authority and credibility in its engagement with policy processes and major freshwater related events; and,
- to raise the awareness and increase the profile of the freshwater biodiversity crisis.

Bearing in mind that one of the main objectives of the FCC is to generate and communicate information that contributes to the conservation of freshwater biodiversity, the FCC, the Global Centre for Species Survival - Indianapolis Zoo and Shoal Conservation, have developed the "Freshwater Species at Risk" initiative. This aims to use 50 freshwater species representing 10 taxon groups (mammals, birds, amphibians, reptiles, fish, plants, fungi, molluscs, freshwater crustaceans and insects), to highlight the need for freshwater conservation around the world. The report will "*showcase these 50 freshwater species at risk, as a communication and fundraising tool for freshwater species research and conservation*".

Seven criteria were used to identify relevant "flagship" species that best represent the range of freshwater diversity (taxonomically, geographically, ecologically). In late-2021 the CSG was invited to nominate crocodilian species that may fit these criteria. The final list of 5 reptiles was announced in

January 2022, and comprised two crocodilian species [African Slender-snouted Crocodile (*Mecistops cataphractus*), Cuban Crocodile (*Crocodylus rhombifer*)], two turtles [Coahuila Box Turtle (*Terrapene coahuila*), Nubian Flapshell Turtle (*Cyclanorbis elegans*) and one lizard [Blue Mountains Water Skink (*Eulamprus leuraensis*)].

It is hoped that the report will be released in time for International Day for Biological Diversity (22 May 2022).

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

Oryx Journal

The IUCN SSC Chair's Office and "Oryx - The International Journal of Conservation" (https://www.oryxthejournal.org), have announced a new partnership fund that will help cover the publication costs of 11 papers authored by SSC members. Financial resources for this initiative were provided by the Environmental Agency-Abu Dhabi.

To qualify, the first or corresponding author must be: a SSC member; their SSC affiliation must be included in the author details; and, the manuscript must report research carried out as part of the work of the SSC group with which they are engaged. Manuscripts can be submitted at: mc.manuscriptcentral.com/oryx.

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 January-March 2022 quarter, and an additional application is currently under review.

1. Urvie Dave (India): Monitoring Mugger crocodiles and their habitat through UAV in the Charotar region, Gujarat, India.

2. Nathan Fernandes Neves (Brazil): Evaluation of mutations in blood cells of *Caiman latirostris* in agricultural landscapes of Alto Paranapanema, southeast Brazil.

3. Everett Madsen (USA): Influence of nest substrate on American Crocodile (*Crocodylus acutus*) hatchling viability in Belize.

Tom Dacey, *CSG Executive Officer (csg@wmi.com.au)*.

26th CSG Working Meeting

The Government of Quintana Roo has reiterated its commitment to host the 26th CSG Working Meeting in Chetumal, Quintana Roo, Mexico, on 3-8 July 2022. It is anticipated that parts of the meeting will be "virtual" (eg via "Teams"), to allow the participation of people who are unable to travel and/or participate in person.

Organisors have advised that the meeting webpage (https://www.biodiversidad.gob.mx/planeta/csg2021/index.html) will be updated to reflect the latest information, including, COVID-19 protocols and sanitary measures likely to be in place for the meeting.

Workshops (Drones, Taxonomy, Veterinary Science) are still planned for 3 July, and the CSG Steering Committee will hold a virtual meeting on 4 July.

Tom Dacey, *CSG Executive Officer (csg@wmi.com.au)*.

50th Anniversary of First CSG Working Meeting

In 2021, the CSG celebrated the 50th anniversary of its first working meeting, held in New York in 1971. This inaugral meeting established the foundation for the biennial working meetings that were to follow (Siroski 2021), and brought together 17 participants from 8 countries - a far cry from recent meetings that can exceed 300 participants from all around the world.

It was intended to celebrate the anniversary during the 26th CSG Working Meeting, which was initially scheduled to take place in 2020. However, the COVID-19 pandemic led to postponement of the meeting, and so it was decided to commemorate this anniversary milestone through a short video. The video features presentations by various CSG members who provide an overview of the history of the CSG, including; Colette Adams, Jen Breuggen, Jon Hutton, Dietrich Jelden, Hank Jenkins, Alejandro Larriera, Christine Lippai, Bill Magnusson, Charlie Manolis, Obdulio Menghi, Christy Plott, Simon Pooley, Perran Ross, Pablo Siroski, Alvaro Velasco, Grahame Webb, Rom Whitaker and Phil Wilkinson. The video also pays tribute to those CSG members who have passed away, and acknowledges their contribution to crocodilian conservation and the CSG.

The occasion of the CSG's 50th anniversary presents a unique opportunity for CSG members to review the changes in crocodilian conservation and management that have occurred over the past half century, and to acknowledge the role that the CSG and its members have played in the progress made. It is also an opportunity for younger and newer CSG members to acquaint themselves with the CSG pioneers, and get some measure of the responsibility they will have for continuing the work of the CSG into the future.

In 1971, with most crocodilian populations depleted globally

due to overexploitation, the focus of the first CSG Working Meeting was "status" of wild populations. Captive breeding was perceived as the safest option, and use of wild populations was not encouraged. But by the 1980s the CSG recognized that sustainable use was a legitimate conservation strategy, and by the late 1980s did an "about face" and adopted sustainable use as a centerpiece for conservation action - the successful conservation results that followed are testament to the success of this change in direction. But although many problems have been solved, there still remain many that are unsolved, and the CSG continues to meet those challenges through the strength and diversity of its membership.

Within the IUCN Species Survival Commission, the CSG is currently one of the largest specialist groups; these vary greatly in terms of size, membership criteria, structure, etc. Unlike some specialist groups, the CSG has not adopted restrictive membership criteria, and so its membership comprises a diverse group of people representing industry, zoos, academia, scientists, wildlife managers, NGOs, educators, etc., all of whom are committed to the long-term conservation of the world's crocodilians.

In 1988, at the CSG's 9th Working Meeting (Lae, Papua New Guinea), then Chair Wayne King established a Steering Committee, for increased communication and to assist the Chair with the work of the CSG (King 1989). The first Steering Committee meeting, involving 9 members, was held in February 1989. By the end of 1990, the Steering Committee membership had risen to 23 members - today it has 71 members representing 8 regions, 5 thematic groups (Industry, Taxonomy, Zoos, Legal, Veterinary Science), a Red List Authority, two working groups (Traceability, Drone) and the Future Leaders Program.

Twenty years later, at the CSG's 19th Working Meeting (Santa Cruz, Bolivia, 2008), an Executive Committee was formally established, initially comprising the Chair, two Deputy Chairs and the Executive Officer. At the CSG's 24th Working Meeting (Skukuza, South Africa, 2016), the Executive Committee was expanded to its current structure of Chair (Grahame Webb), Executive Officer (Tom Dacey) and four Deputy Chairs (Alejandro Larriera, Christine Lippai, Charlie Manolis, Perran Ross).

Not only has the CSG changed significantly in size over time, from the handful of members at the first Working Meeting in 1971, to a little over 700 members from 70 countries today. It has also changed in terms of gender representation. In 1989, there were 4 female members (5% of membership), by 2003 there were 17 female members, and today there are 129 female members. This trend is also reflected in the composition of the Steering Committee. Between 1989 and 2003, only four women had served on the Steering Committee at different times (Ginette Hemley, Ruth Elsey, Lorraine Collins, Lucy Aquino). In early 2004, only two women were on the Steering Committee - this number has now increased to 12.

To some extent, this change reflects the way that women perceive "working" with crocodiles in more recent times. The CSG's Student Research Assistance Scheme (SRAS) and Fritz Huchzermeyer Veterinary Science Student Research Assistance Scheme (FHVS-SRAS) provide an index of students carrying out work on crocodilians globally - 44% of applicants have been women! The SRAS/FHVS-SRAS program has been a significant initiative for the CSG, with 220 projects in 42 countries funded over the last 13 years, encouraging and assisting students to undertake formal research on crocodilians.

Recognising the need to identify and mentor future leaders, in 2014 the CSG established a Future Leaders Working Group (FLWG), which identified potential future leaders, and provided skills transfer to FLWG members, thereby extending institutional memory. The FLWG also introduced its members to the Convention on International Trade in Endangered Species of Wild Fauna and Fauna (CITES), facilitated involvement in IUCN Red List determinations, encouraged participation in various professional forums, and fostered improved networking within the CSG (see Webb *et al*. 2020). The initiative has resulted in some members of the FLWG taking up leadership roles within regional/thematic groups on the Steering Committee. The FLWG has now been replaced by the dedicated Future Leaders Program (FLP), and is currently chaired by Pablo Siroski.

The CSG's gratitude and thanks are extended to: Pablo Siroski and Alejandro Larriera who coordinated video content and presentations; Alexandro Irusta who edited the video; and, Ruth Elsey, Dietrich Jelden, Simon Pooley, Luis Sigler, Pablo Siroski, Phil Wilkinson and Allan Woodward for photographs.

The 50th anniversary video can be viewed on YouTube, at: https://www.youtube.com/watch?v=SqM6NcNhUTw.

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Charlie Manolis and Alejandro Larriera, *Interim Joint CSG Chairs (cmanolis@wmi.com.au)*.

Women in Crocodilian Research, Management and Conservation

International Women's Day (IWD), held on 8 March annually, is a global day that aims to celebrate the social, economic, cultural and political achievements of women (https://www.internationalwomensday.com/about). It is within this context,

and the 50th anniversary of its first CSG Working Meeting (Siroski 2021; Manolis and Larriera 2022) that we decided to submit this short article.

To the general public, working with large dangerous predators such as crocodilians, is often not perceived as something that a woman should be doing. In fiction, it was always Tarzan, not Jane, who was diving into the river to fight the crocodile with his bare hands, dramatically reflecting these old biases! Interestingly, even male colleagues working with crocodilians have remarked that they too are often asked: "aren't you afraid?"

However, as women working in the field with crocodilians, this automatically places us in a position open for comparisons, including doubtful questions as to whether we are capable of doing the work. For women, the answer to the questions is very clear: "we are not afraid, and yes, we are fully capable of carrying out this type of work". Women can withstand intense efforts in the field, often under adverse conditions (eg weather, logistic difficulties). Women have the temperament to handle large predatory reptiles. Over time, women have managed to raise their visibility and demonstrated the role and empowerment of women in different sectors, even though at times this has not always been easy, especially when cultural and social customs place women in default roles.

Within the CSG, women have played increasing roles throughout its 50-year history. Indeed, the CSG is a good indicator of the changes that have occurred with regard to the involvement and recognition of women in crocodilian research, management and conservation (see Manolis and Larriera 2022). From the first CSG Working Meeting in 1971, women have been active participants in Working Meetings, regional meetings, etc. Of the 17 participants at the first meeting, three were women [Moira Warland (IUCN, Switzerland), Claire Hagan (Reptile Products Association, USA), Deborah Besch (Secretary, USA)]. This participation has continued and increased through subsequent meetings, and is particularly evident in recent years (see Fig. 1).

It is also important to highlight the women who have been awarded the Castillo Award for Crocodile Conservation, in recognition of their significant contributions to crocodilian conservation [Jenny Daltry (Cambodia, 2004), Zilca Campos da Silva (Brazil, 2008), Alison Leslie (South Africa, 2016)]. In 2018 (Argentina, 2018), the Castillo Award was presented to Proyecto Yacare from Argentina - a large research group that comprises around 75% women!

As mentioned, the contributions of women within the CSG have been steadily increasing, with key inputs in areas ranging from genetics, systematics, ecology, veterinary science and social work, to topics related to industry and commerce. In 2016 (South Africa), expansion of the CSG Executive Committee included the appointment of Christine Lippai as a Deputy Chair, mirroring a trend that has seen more women taking on roles within the CSG Steering Committee (see Manolis and Larriera 2022).

Figure 1. Female participants at the Borneo Crocodile Forum (top; 2014), and 23rd (middle; Louisiana, 2014) and 25th (bottom; Santa Fe, 2018) CSG Working Meetings.

The significant increase in the number of female members in the CSG since 2004 largely reflects the increasing participation of women in crocodilian activities around the world, and the CSG's "no discrimination" policy with regard to gender. We hope that this will lead to increasing acceptance and involvement of women in the field of crocodilian research, management and conservation.

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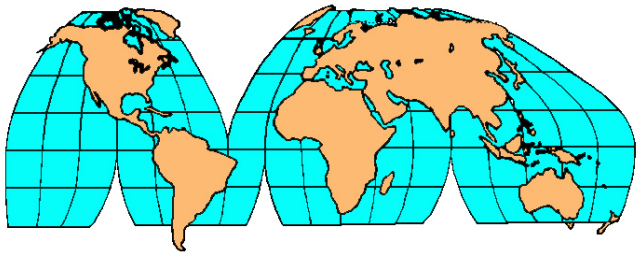
Regional Reports



South Asia and Iran

SURVEY OF HUMAN-CROCODILE CONFLICT IN NON-PROTECTED AREAS OF KENDRAPARA DISTRICT, ODISHA, INDIA. In India, depleted populations of crocodilians have been managed by supplementation since 1975-76 under "Project Crocodile" - a Government of India initiative. While most crocodile enthusiasts are usually very supportive of such efforts to recover endangered crocodilian populations, most large crocodilians are potential predators of humans and/or livestock, and these recoveries can quickly turn into conflicts (CSG 2021).

In Odisha, the Saltwater crocodile (*Crocodylus porosus*) is restricted to the mangrove swamps of the Brahmani-Baitarani Delta in the state's northeastern region, which is protected by Bhitarkanika National Park (Nayak *et al*. 2018). Around the mid-1970s, the *C. porosus* population was down to critical numbers, leaving only a small viable population in the main Bhitarkanika River and a few adjoining creeks. The population decline was mostly associated with indiscriminate hunting (Nayak *et al*. 2018). Taking stock of the situation, a conservation program (rear and release) was launched by the State Forest Department. Eggs were collected from wild nests, artificially incubated and 1.2-m head-started crocodiles were released into the river and creeks to rebuild depleted populations. The presence of all age/size classes in annual population count surveys is a sign of a healthy and viable population (Fig. 1).

Figure 1. Juvenile *C. porosus* often disperse far to colonize new habitats where there is little/no competition.

People have been living close to these crocodiles for a long time, but conflict seems to be recent. Human populations in these villages have gradually increased, and more people have now moved closer to crocodile habitats for better access to water for their daily needs. This survey was carried out in Kendrapara District on the outskirts of Bhitarkanika Sanctuary. All the communities surveyed depend on the flowing river and creeks for bathing, washing clothes and sometimes for drinking water for cattle and people. The water bodies are connected to the main Brahmani River that flows into BNP. The crocodile population includes some large males that take adult cattle. The Odisha State Forest Department (OSFD) reported an average of 3.1 cattle (range 1-5) killed per year by crocodiles between 2003 and 2010. Compensation given by the State Government is Rs 5000 for loss of cattle and Rs 200,000 (upgraded from Rs 100,000 in 2012) for loss of human life.

Most non-fatal attacks go unreported, as there is no compensation for minor injuries. Compensation of Rs 75,000 is offered in case of permanent disability, where certified by a registered medical practitioner.

Communities continue to use the water bodies in all the villages with minimal safety measures. Almost all fatal attacks have taken place when the victim was bathing in shallow waters close to the bank (Table 1).

Based on the information gathered from OSFD, the majority of the attacks on humans in BNP occur when people enter crocodile habitats for illegal fishing, poaching, collection of wood, honey, etc. Most of the attacks occur during the rainy season when the riverbanks are inundated by high tide or flood waters. However, information collected during the survey suggests that attacks also occur in places where people live in crocodile habitats that are outside the national park.

A rapid survey of human-crocodile conflict outside protected areas of Kendrapara District, Odisha, was carried out on 7-9 October 2013. The aim was to carry out the survey in locations of human-crocodile interactions and further explore mitigation measures with long-term impact that may be best suited to these specific areas. Data were gathered from the office of the district collector, emergency response office, and office of the Divisional Forest Officer (OSFD).

Details of crocodile attack sites, crocodile sightings, affected villages and communities, were recorded during the visit. Interviews were conducted with victims, family members, and interested residents. Each case was recorded separately with details like date, place, name, sex and age of victim, activity during attack, time of day, etc. Much of the detailed information regarding incidents was related to human injury/fatality, and little information other than location of an attack was reported for injury/fatalities related to livestock. All the locations visited were on the fringes of the protected sanctuary area.

Details of fatal attacks since 2008 in Rajnagar block (non-protected areas), based on information from OSFD after the compensation mechanism for loss of human life was put in place by Government, are in Table 1.

The data indicates a direct relation to the structure of the river/creek at that site. In all the surveyed locations, the bottom of

Table 1. Details on human fatalities (N= 13) due to crocodiles in Kendrapara District, 2003-2013 (Source: Odisha State Forest Department).

Year	Block	Location	Activity
2003-04	Raikanika	-	bathing
2004-05	Kendrapara	-	bathing
2005-06	Kendrapara	-	bathing
4 May 2008	Kendrapara	Baitarani Creek	bathing
10 August 2009	Kendrapara	Khorstrota Creek	bathing
22 August 2009	Kendrapara	Baitarani Creek	bathing
17 May 2010	Raianika	Kharashorta at Jamudanda	bathing
10 September 2011	Rajnagar	Brahmani tributary	bathing
25 October 2011	Raikanika	Baitarani Creek	washing clothes
9 May 2012	Rajnagar	Brahmani River	bathing
12 June 2012	Rajnagar	Brahmani tributary	bathing
2012-13	Rajnagar	Brahmani tributary	bathing
25 July 2013	Rajnagar	Brahmani River	bathing

the river or creek runs shallow for 3-5 m towards the middle and as deep as 8 m or more in the centre, making it extremely difficult to spot an approaching crocodile, but very easy for a crocodile to approach and attack.

The proximity of these water bodies to the houses in any given village is uniform. Average distance between houses on the banks was 15-25 m. This is an important factor as this allows easy access to the water and being so close to their houses, people feel less threatened by the crocodiles in the water, a dangerous misconception (Figs. 2-4).

Figure 2. Location of fatal attack in June 2012, at Rajnagar, on a Brahmani tributary.

Figure 3. Location of fatal attack in July 2013, at Rajnagar, on a Brahmani tributary.

Figure 4. Location of fatal attack in September 2011, at Rajnagar, on a Brahmani tributary.

Thirteen fatal attacks in the area between 2003 and 2013 (Table 1) is far less than expected, especially when thousands of people use the water resources every day. People also seemed tolerant of these animals, which indicates that mitigation measures are implementable.

Conclusions

The OSFD is sensitized to HCC, and has been involved in creating 'safety barriers' using logs. However, this has not proven to be effective due to inappropriate designs and often poor choice of materials. The barriers observed during the

survey were worn out and the numbers of them were inadequate (Figs. 5 and 6). Other than the provision of compensation for the fatal attacks there is need for communication to bridge the disconnect between the community and the forest department along with improved messaging and awareness among the people.

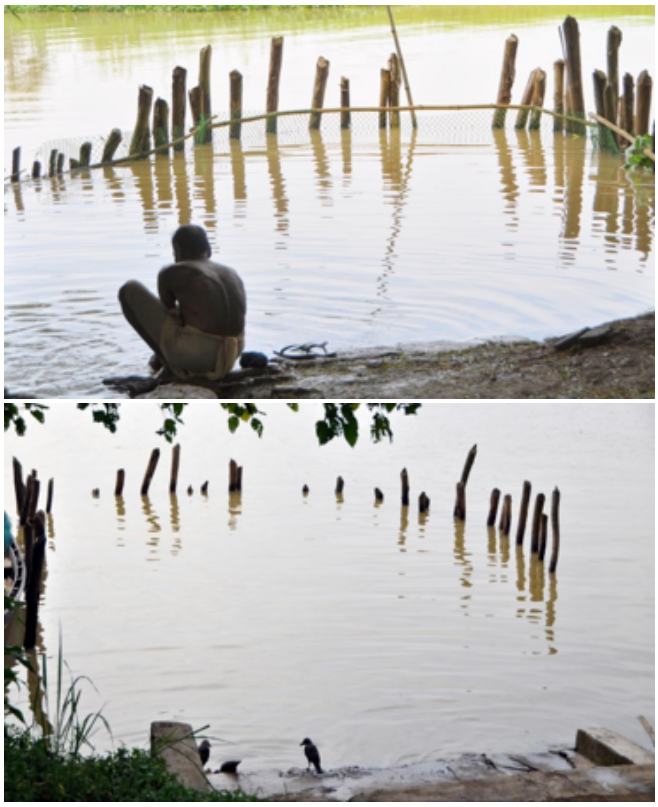


Figure 5. "Safety barriers" erected by the Odisha State Forest Department.

Figure 6. Balaram Patra stands where he experienced a non-fatal attack in June 2010, at Ostia village. The forest department constructed this 'safety barrier', which has worked as a deterrent, but is not a secure system as there are many gaps and missing timber through which a crocodile can pass.

It is evident that the direct use of the water bodies by the communities increases the risk of conflict. This, plus change in land use patterns, where land adjoining the river is cleared for agriculture leaving no place for the crocodiles to retreat and no "buffer" space for people has led to more conflict. Villages have established on riverbanks, and typically, the poorest communities from these villages are pushed to the most vulnerable locations. In these situations, where crocodiles end up living near people, large crocodiles see easy prey (eg a bathing human) and may hunt instinctively. Although residents displayed an understanding of the risks of crocodile attack, very few actually utilised protective barriers when at the river.

There is an urgent need for holistic mitigation and sensitization programs for the communities. Attitudinal change will always go a long way in any conservation management plan.

Suggested mitigation measures include:

1. Crocodile Exclusion Enclosures (CEE): Most people take little/no precautions when collecting water or washing. CEEs can be built where the risk is high. The use of physical structures to exclude crocodilians and reduce the risk of attack has been used in different parts of the world. These enclosures should be effectively designed to cater for normal and low water levels, and for when water levels are high (Figs. 5 and 6). Government may build the enclosures at common points in the villages. However, for individual households, people must be encouraged to create and use protective barriers and maintain them.

2. Sensitization initiatives: There needs to be sustained messaging to create awareness amongst rural people regarding steps to be taken to safeguard their lives when using habitats containing crocodiles (Fig. 7). This awareness may include the steps to be taken to prevent an attack, reporting in case of an attack, compensation schemes, etc. This information can be communicated with signage along the riverbanks, in schools/ panchayats and in other places frequented by locals.

Figure 7. Direct, unsafe contact with the river system make the situation highly vulnerable to conflict with crocodiles.

3. Creating wells next to rivers: Communities may be encouraged to dig wells close to rivers, especially in locations with a high water table so that water can be collected safely.

4. Water storage tanks: Communities may be encouraged to build storage tanks water that can be used for bathing and washing purposes.

Acknowledgements

We would like to thank: Mr. Jay Panda (Member of Parliament, Rajnagar) for organizing this survey and helping with logistics; Mr. Manas Das from the Office of the Collector, Kendrapara, for helping with accommodation, transportation, and for accompanying during field surveys; and, Mr. Kedar Swair, Regional Forest Officer, Rajnagar, for sharing crocodile attack data in his region. We also thank the interviewed villagers, some of whom have lost loved ones and/or survived dangerous encounters.

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Soham Mukherjee, *NAJA India, 18 Shubhkamna Society, Anandnagar Road, Ahmedabad, Gujarat, India* and Gowri Mallapur, *GaiaMitra Collective Foundation, Porvorim, Bardez, Goa, India*.

ANNUAL CENSUS OF ESTUARINE CROCODILES, *CROCODYLUS POROSUS*, IN THE RIVER SYSTEMS OF BHITARKANIKA NATIONAL PARK, ODISHA, INDIA (2022). The annual census of Estuarine crocodiles (*Crocodylus porosus*) was conducted in the river systems of Bhitarkanika National Park/Wildlife Sanctuary (Fig. 1), on 6-9 January 2022. Twenty-two census units (54 segments) were surveyed in the identified rivers and creeks.

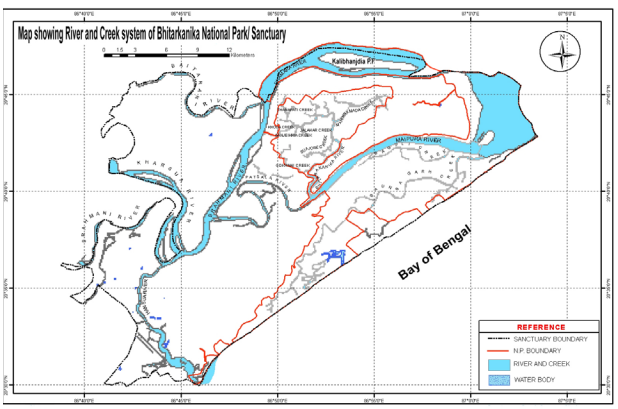

Figure 1. Rivers and creeks of Bhitarkanika National Park/ Wildlife Sanctuary.

Surveys were carried out during the day and night, with crocodiles over 1.8 m (6') in length (ie sub-adults and adults) counted during the day, and hatchlings (<0.6 m), yearlings (0.6-0.9 m) and juveniles (0.9<1.8 m) counted by spotlight at night. Climatic conditions for surveys were good, with clear and sunny weather, low day and night temperatures and favourable tidal conditions (Fig. 2).

Figure 2. Although crocodiles may be seen at high tide, surveys are underken at low tide to maximise the number of sightings. Photograph: Nirakar.

A total of 1784 crocodiles was counted, which included; 564 hatchlings (31.6%), 378 yearlings (21.2%), 338 juveniles (19.0%), 158 sub-adults (8.9%) and 346 adults (19.4%). Of the 1784 counts, 1405 were in the Kanika Wildlife Range, which included Forest Blocks and rivers from Khola to Bhitarkanika-Pathasala confluence and beyond in the Bramhani-Baitarani River systems. This was followed by 265 crocodiles in Rajnagar WL Range. Within the Mahanadi delta, 76 crocodiles were counted in Mahakalapada Wildlife Range and 34 in Gahirmatha Wildlife Range. Notwithstanding differences in survey units, survey results indicate an increase of 16 counts relative to the January 2021 census (1768 counts; Kar 2021). There were 64 crocodiles over 4.9 m (16') in length (Figs. 3 and 4), including 4 crocodiles >6.1 m (20').

In 1976-77, the 96 *C. porosus* were counted in Bhitarkanika Wildlife Sanctuary, including 35 adults (Kar 1979; Kar and Bustard 1989). Due to implementation of the Government of India/FAO/UNDP Project "Crocodile Breeding and Management" in Bhitarkanika National Park/Wildlife Sanctuary since mid-1975, with more than 3000 young captive-reared crocodiles being released in suitable rivers and creeks since 1977, depleted population has been built up gradually over the last 45 years (Kar 2021). Relative density has increased from 0.87/km in 1976 to 13.50/km in 2022.

More than 105 female Estuarine crocodiles (both released and wild), including leucistic crocodiles (known locally as "Sankhua"), have nested successfully (Fig. 5) - a 17 times increase compared to the mid-1970s with respect to nest production in the wild.

Figure 3. Adult male Estuarine crocodile (>4.9 m TL) basking on riverbank. Photograph: Sudhakar Kar.

Figure 4. Adult male Estuarine crocodile (>5.5 m TL) exposing only dorsal portion of the body to sun while the rest of the body is in water. Photograph: Palei Bhakta.

Figure 5. Leucistic female Estuarine crocodile (~3 m TL) basking at water's edge. Photograph: Sudhakar Kar.

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CROCODILE FOSSIL RECORDS FROM GUJARAT, INDIA. Crocodilians and their allies are defined as 'Archosaurs', with a fossil record extending back to the Triassic. At the time of their classification, Linnaeus and Salvii (1758) and Gmelin (1789), were only aware of the extant forms of crocodilian. Because early systematists worked with limited knowledge and understanding of fossil records or evolution, Linnean groups consisted only of extant taxa - groupings that today would be termed as "crown groups" in phylogenetic terms. A crown group means all modern crocodilians - the 27 currently recognized species of alligator, caiman, crocodile and gharial (Stevenson 2019).

The earliest published accounts of fossil crocodyliforms emphasized the dissimilarities with modern crocodilians. Later, this point of view quickly changed to that typified by Buckland (1836), who stated that fossil of the crocodilian family do not deviate sufficiently from the living genera to require any description of peculiar and discontinued contrivances. The reason - that there have always been semiaquatic ambush predators with flattened snouts among crocodyliforms, very little fundamental change is perceived, and crocodilians are seen as having remained morphologically static since the Mesozoic period.

Within an Indian context, there has been little paleontological research on crocodilian fossils, relative to other parts of the world. Crocodilian fossil records from India come mainly from the diversified crocodilian fossil distribution from Gujarat State, especially from two areas, Piram Island and Kutch.

Kutch

The geology of Kutch is very interesting, as it comprises of rocks ranging in age from Jurassic to present day. The Mesozoic rocks of Kutch have attracted the attention of geologists from all over the world, mainly because of the exceptional richness of fossils from the Jurassic Period. Palaeontological studies emphasize Kutch as the best area for studying fossils from various ages and periods of evolution.

The fossil history and the pool of palaeontological knowledge suggest that Western Kutch once comprised diverse habitats, with a multitude of swamps supporting rich flora and fauna. Most of the crocodilian fossils belong to Tomistomine groups, either relatives of the modern Tomistomine or belonging to Tomistomidian affinities (longirostrine crocodilians dating to period between late Miocene to early Eocene) (Table 1).

Figure 1. Ventral surface of fossil skull of unidentified crocodylomorph excavated by Dr. Hansh Thewissen from Julrai village, Lakhapat, Kutch District, and now exhibited at Bharatiya Sanskruti Darshan Museum, Bhuj, Kutch, Gujarat, India. Photograph: Raju Vyas.

Piram Island

Piram Island (Bhavangar District) is located in the Gulf of Khambhat (previously Gulf of Cambay), and is known to support multiple fossil records, including crocodilians. The island covers an expanse of about 7.5 km^2 across an intertidal zone, with 1.5 km^2 comprising unsubmerged land area. It is surrounded by rocky reefs which run 3-5 km to the north and southeast, and which are exposed on low tides.

The geology of Piram is complex, and it appears to have been formed during the Pliocene and Holocene periods. The vertebrate bonebed and round pebble conglomerate subfacies were formed even prior to this period, during the Upper Miocene to Lower Pliocene. The thickness of these rocks varies from 1 to 15 m; the strata represents mammalian and non-mammalian vertebrate bone fossils.

The vertebrate fossils at Piram Island have attracted attention for over 175 years (Falconer 1845; Ferreira *et al*. 2018). Fossils representing most living groups have been discovered, along with many fossils representing extinct groups. The common fossil species are Probocidia, Ungulata, Chelinia, Pisces and Crocodilia (Prasad 1974). The oldest fossil representative of the genus *Gavialis*, from the late Miocene, is also from Piram Island (Falconer 1859; Martin 2018).

Other fossil records from different parts of India include fossilized teeth (alligatorine), vertebrae and teeth (ziphodont bearing Pristichampsinaes crocodilians - a more terrestrial form of crocodile) belonging to a Cretaceous crocodilian found at Rangapur (Rana 1990) and Naskal (Prasad and Lapparant 2002), Andhra Pradesh, India, respectively. Also, the recent paleontological review of reptilian fossils includes crocodilian fossils of Piram (see work of Falconer 1859; Lydekker 1886) and Pinjor beds of the upper Shivalik foothills of the Himalayas, and considered fossils of *Crocodylus* aff. *palustris*; *Gavialis* cf. *gangeticus* and *Rhamphosuchus crassidens* (beak crocodile) (Nanda *et al*. 2016; Martin 2018).

Acknowledgments

I am grateful to the curator of Bharatiya Sanskruti Darshan Museum for allowing me to examine their fossils, and special thanks to Dax Pandhi, Mahim Pandhi Wildlife Foundation, Bhuj, Kutch, for support during the visit to Kutch.

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Table 1. Noteworthy crocodilian fossils from Kutch, Gujarat, India.

Species	Description	Location	Source
Crocodylus sp.	Premaxilla with alveoli of three teeth	Harudi, Lakhpat 23° 30' 20", 68° 41' 15"	Sahni and Mishra (1975)
Tomistoma tandani	Partial Skull, mandible, vertebrae	Nardi (=Nareda), Lakhpat 23° 29' 10", 68° 41' 00"	Sahni and Mishra (1975)
Tomistomidian affinities	Upper jaw with few teeth	Sukhpar, Abdasa 23° 22' 25", 68° 44' 55"	Vijayasarathi and Sabale (1985)
Tomistoma sp.	Part of premaxilla with few teeth	Samda (=Sambhada), Lakhpat 23° 29' 58", 68° 51' 16"	Patnaik *et al*. 2014
Unidentified	Part of skull (see Fig. 1)	Julrai, Lakhapat 23° 29' 50.8", 68° 46' 9"	Housed at Bharatiya Sanskruti Darshan Museum, Bhuj, Kutch

Gujarat, India. PeerJ 6: e5938.

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"PANIRA RAJA KUMBHIRA" - CROCODILE: THE KING OF WATER. Written in Odia language (official language of Odisha State, India), "Panira Raja Kumbhira" (Crocodile: The King of Water) (Fig. 1) is based on the first-hand experiences of Lala Singh and Sudhakar Kar, whose names are synonymous with conservation of Indian crocodilians.

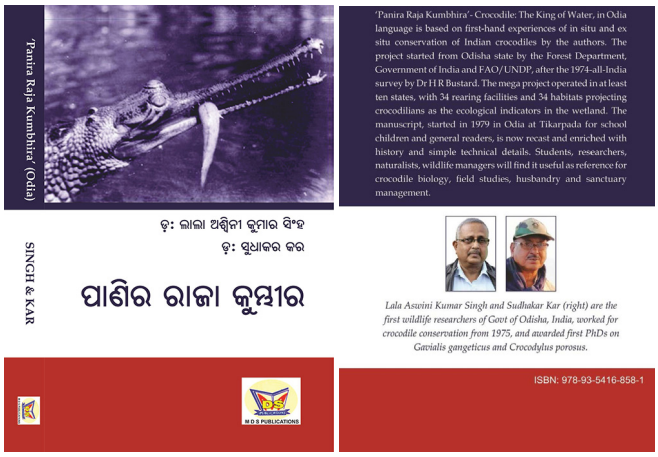

Figure 1. Front (left) and back (right) covers of Panira Raja Kumbhira.

The original manuscript, started in 1979 for school children and general readers, has now been recast and enriched with history and technical details. The authors hope that it will be a useful reference for students, researchers, naturalists, wildlife managers, etc.

A book launch took place on 20 November 2021, at the Bigyan O Paribesh Congress (Science and Environment Congress) held at Ravenshaw University, Odisha, India (Fig. 2).

Figure 2. Book launch with authors Lala Singh and Sudhakar Kar (3rd and 4th from right, respectively).

A detailed brochure is available at: http://www.iucncsg.org/content_images/attachments/Kumbhira%20Flier%20CSG%20Newsletter.pdf.

North America

USA

EYE ABNORMALITY IN AMERICAN ALLIGATORS (*ALLIGATOR MISSISSIPPIENSIS*). Numerous studies have evaluated abnormalities, injuries and diseases in crocodilians (eg Huchzermeyer 2003; Webb and Messel 1977; Webb and Manolis 1983; Youngprapakorn *et al*. 1994), including ocular disease (Rainwater *et al*. 2011). Normally the crocodilian eye has a pupil that contracts to a vertical slit in bright sunlight (Webb 1977).

On 1 June 2020, a nuisance male alligator (*Alligator mississippiensis*) measuring 2.26 m TL was caught in the vicinity of Lydia, Iberia Parish, Louisiana. It was in good body condition and described as "very healthy", although it had a superficial wound on its right flank and some old bite marks on the body. Upon closer inspection, the right pupil was atypical and rounded in shape (Fig. 1), rather than the normal vertical slit orientation. The left pupil seemed cloudy and was thought to have had old trauma or a cataract (Fig. 1). The alligator was euthanazed, and the eyes were placed in formalin for histological examination.

Interestingly, the right eye had no gross abnormalities seen upon veterinary inspection, and histopathology showed no significant abnormality or lesions in the examined section. The left eye was approximately one-third smaller than the right and a diagnosis of "phthisis bulbi with moderate chronic conjunctivitis" was made. These changes were consistent with old trauma with prolapse, mild scarring, and loss of normal intraocular structures (including cornea, lens, retina, and choroid).

Unexpectedly, about 6 weeks later we were called to catch a nuisance alligator at the local school near Rockefeller Wildlife Refuge in Cameron Parish. The female alligator was 1.65 m TL, in good condition, exhibited a similarly unusual rounded pupil in its left eye (Fig. 2). The left pupil was rounded rather than having a vertical slit, while the right eye had the typical crocodilian appearance (Fig. 2). A blood sample was collected for an unrelated study, and the alligator was released on the refuge.

Visual acuity was not tested in either alligator, but we presume they were able to successfully hunt and capture prey, as they were not emaciated and appeared well nourished. We are curious as to whether this rounded (rather than a vertical slit) appearance of the pupil is a normal morph and if it has been observed in other crocodilians. The prevalence of this finding might also be of interest.

Figure 1. Round pupil in right eye (left) and abnormal left eye resulting from trauma (right), in a 2.26 m male *Alligator mississippiensis*.

Figure 2. Unusual left pupil (left) and normal pupil in right eye (right) in a 1.65 m female *Alligator mississippiensis*.

Acknowledgements

We thank Jordan Broussard for assistance with capture and transport of the alligator caught in Cameron Parish.

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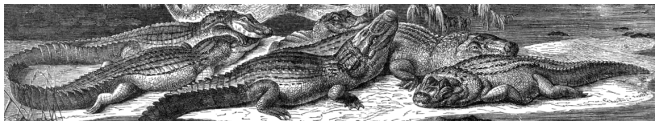

Recent Publications

Kock., R. and Caceres-Escobar, H. (2022). Situation Analysis on the Roles and Risks of Wildlife in the Emergence of Human Infectious Diseases. IUCN: Gland, Switzerland.

Abstract: This situation analysis presents a thorough, evidence-based examination of the relationship between wildlife and zoonosis, wildlife and emerging human pathogens and associated diseases, their origins, drivers, and risk factors. There is considerable divergence of opinion around the subject both within and outside the biodiversity conservation community and given the ontological challenges and highly different perspectives, contradictory narrative is unsurprising. Context is all-important and to clarify this in the analysis, the evidence of human diseases coming from wildlife is compared to diseases emerging from domestic animals and humans themselves, to provide context and proportions of the relative risk. The report highlights key knowledge, and provides perspective on where research, policy, interventions, and capacity building are needed to reduce risks of zoonoses and emergent animal-origin human diseases globally.

Byas, A.D., Gallichotte, E.N., Hartwig, A.E., Porter, S.M., Gordy, P.W., Felix, T.A., Bowen, R.A., Ebel, G.D. and Bosco-Lauth, A.M. (2022). American alligators are capable of west Nile virus amplification, mosquito infection and transmission. Virology (https://doi.org/10.1016/j.virol.2022.01.009).

Abstract: West Nile virus (WNV) overwintering is poorly understood and ikely multifactorial. Interest in alligators as a potential amplifying host arose when it was shown that they develop viremias theoretically sufficient to infect mosquitoes. We examined potential ways in which alligators may contribute to the natural ecology of WNV. We experimentally demonstrated that alligators are capable of WNV amplification with subsequent mosquito infection and transmission capability, that WNV-infected mosquitoes readily infect alligators and that water can serve as a source of infection for alligators but does not easily serve as in intermediate means for transmission between birds and alligators. These findings indicate potential mechanisms for maintenance of WNV outside of the primary bird-mosquito transmission cycle.

Villegas, A., Rojas-Santoyo, A. and Ulloa-Arvizu, R. (2022). Population genetics and molecular identification of *Crocodylus acutus* and *C. moreletii* (Crocodilia: Crocodylidae) in captive and wild populations. International Journal of Tropical Biology 70 (doi: 10.15517/RBT.V70I0.46962).

Abstract: There is low evidence of genetic diversity and hybridization processes within *Crocodylus acutus* and *C. moreletii* populations. Objetive: To evaluate genetic diversity and some phylogenetic relationships in wild and captive populations of *C. acutus* and *C. moreletii* using the Barcode of Life Data System (COX1, cytochrome C oxidase subunit 1 gene). Twenty-eight (28) individuals phenotypically like *C. acutus* located in the states of Guerrero, Oaxaca and Quintana Roo were sampled, as well as animals belonging to *C. moreletii* located in the states of Tabasco, Campeche, and Quintana Roo. 641 base pairs of nucleotide sequence from COX1 were used to obtain the haplotype and nucleotide diversity per population, and a phylogenetic and network analysis was performed. Evidence of hybridization was found by observing *C. moreletii* haplotypes in animals phenotypically determined as *C. acutus*, as well as *C. acutus* haplotypes in animals classified as *C. moreletii*. Low haplotypic diversity was observed for *C. acutus* (0.455 ± 0.123) and for *C. moreletii* (0.505 ± 0.158). A phylogenetic tree was obtained in which the sequences of *C. acutus* and *C. moreletii* were grouped into two well-defined clades. Organisms identified phenotypically as *C. acutus* but with *C. moreletii* genes were separated into a different clade within the clade of *C. moreletii*. There are reproductive individuals with haplotypes different from those of the species. This study provides a small but significant advance in the genetic knowledge of both crocodile species and the use of mitochondrial markers, which in this case, the COX1 gene allowed the detection of hybrid organisms in wild and captive populations. Conservation efforts for both species of crocodiles should prevent the crossing of both threatened species and should require the genetic identification of pure populations, to design effective conservation strategies considering the possibility of natural hybridization in areas of sympatry.

Ratanakorn, P., Chamsai, T., Sedwisai, P., Sujittosakul, T., Lapjatuporn, T., Wongluechai, P., Tiyanun, E., Kunsorn, A.,

Puangdee, S., Chooma, T., Mattayasap, K., Srongmonkol, P., Boonmak, J. and Sangkachai, N. (2021). Population assessment of crocodiles in Bueng Boraphet, Thailand. Journal of Applied Animal Science 14(2): 21-32.

Abstract: This study aimed to estimate the number and distribution of crocodiles in Bueng Boraphet, Nakhon Sawan Province, Thailand. The surveys were conducted between November 2017 and August 2018. The data were obtained from nighttime spotlight and daylight visual surveys using motorboat along two line transects totaling 38 kilometres and covered an area about 7.6 square kilometres of Bueng Boraphet coastal area. Our results revealed that the number of crocodiles was at least 17 individuals with density of 2.24 individuals per square kilometre. The calculated population of crocodiles in the Bueng Boraphet was estimated to be about 17-37 individuals. In this study, most crocodiles were found in the first transect line located in the aquatic sanctuary area where all fishery is strictly prohibited. It shows that human activities directly affect crocodile encounters and these small numbers of crocodiles in Bueng Boraphet remain critically endangered. Therefore, the implementation of protection action is a high-priority project that needs to be done first before further restocking can be undertaken. Bueng Boraphet can be developed into national natural crocodile conservation, while eco-tourism activities can be expanded in such area. Furthermore, population surveys should be carried out continuously to determine population dynamics and develop a crocodile surveillance system. At the same time community engagement should be initiated to support the system to sustainable conservation.

Halaclar, K., Rummy, P., Deng, T. and Van Do, T. (2022). Footprint on a coprolite: A rarity from the Eocene of Vietnam. Palaeoworld (https://doi.org/10.1016/j.palwor.2022.01.010).

Abstract: A rare ichnological example of a crocodilian footprint on an Eocene crocodilian coprolite has been discovered. The enigmatic specimen, measuring 4 cm in length, was found among 100 coprolites at the Na Duong coal mine in Lang Son Province, northern Vietnam. Almost all the discovered coprolites were ascribed to a potential crocodilian producer, suggesting the existence of an ancient lacustrine environment. Furthermore, neoichnological analyses of extant crocodilian footprints also corroborate the inference of a crocodilian as the producer of the footprint. We concluded that the 4-cm-long Na Duong fingerprints most likely belonged to a 2-m long crocodilian whose IV or V finger of the right manus might have made the fingerprints. Since no other records of foot traces or trackways were identified during the fieldwork in the fall of 2018, the Na Duong fossil site should be investigated for further ichnofossil analysis.

Inacio Veenstra, L.L. and Broeckhoven, C. (2022). Revisiting the thermoregulation hypothesis of osteoderms: A study of the crocodilian *Paleosuchus palpebrosus* (Crocodilia: Alligatoridae). Biological Journal of the Linnean Society (https://doi.org/10.1093/biolinnean/blac001).

Abstract: The functional significance of osteoderms - ossified bony structures in the dermis - has been a topic of discussion for many years in biological sciences. Although a protective function has received significant attention in the past, evidence is accumulating that osteoderms might play an important role during physiological activities, specifically thermoregulation. Previous studies have shown that, in crocodilians, the temperature of the skin overlying the osteoderms differs from that of the non-ossified skin during basking. The direction of these differences, however, appears to vary among studies, warranting the re-evaluation of a potential thermoregulatory function. In this study, we explored the thermal benefits of osteoderm expression in dwarf caimans (*Paleosuchus palpebrosus*). We compared the difference in dorsal and lateral skin temperatures (ΔT) between individuals with fully developed osteoderms and those devoid of any osteoderms, under three different temperature gradients. Our results show that although significant differences in ΔT are present between individuals and between temperature gradients, they do not relate to the expression of osteoderms. The findings of the present study question the thermoregulatory role that osteoderms play in *P. palpebrosus*, and vertebrates in general, and we put forward a series of alternative (physiological) hypotheses explaining their enigmatic nature.

Rishi, B. and Singh, H. (2022). Lacoste: Save Our Species Campaign. Pp. 131-138 *in* Socially Responsible Consumption and Marketing in Practice, ed. by J. Bhattacharyya, M.S. Balaji, Y. Jiang, J. Azer and C.R. Hewege. Springer: Singapore.

Abstract:

(a) The situation faced: In February 2018, Lacoste, the famous French lifestyle brand, made a brave announcement at the Paris Fashion Show Week when it announced the release of a limited edition series of polo t-shirts. The series would show 10 endangered species of wild animals as the logo under the Lacoste brand. For nearly a century, Lacoste was identified worldwide by its legendary 'Crocodile' logo. However, the limited edition series was not going to carry it.

(b) Action taken: The polo t-shirts were launched as a part of the 'Save Our Species' campaign in partnership with The International Union for Conservation of Nature (IUCN). IUCN was an international organization that worked to conserve nature and sustainable use of natural resources. The campaign aimed at increasing awareness about the condition of endangered species of animals. Besides, it also aimed at building Lacoste's reputation as a committed and responsible brand. This positioning was considered appropriate for Lacoste because the fashion industry was considered among the world's highly polluting industries. Through this campaign, the company could demonstrate its commitment to environmental responsibility.

(c) Results achieved: The animals used as logos included the Vaquita, the Burmese roofed turtle, Northern Sportive Lemur, Javan Rhino, Kakapot Parrot, Cao Gibbon, California Condor, the Saola, Sumatran Tiger and Anegada Ground Iguana. The series comprised only 1775 polo shirts for all 10 species. The company was committed to supporting IUCN's save our species campaign through this series' sale proceeds.

(d) Lessons learned: Over the years, Lacoste had become synonymous with the crocodile logo. The decision to use the endangered species could position Lacoste favourably as an environmentally responsible brand among ecologically conscious consumers, but would the transference of attributes be so effortless? It could also confuse the loyal customers who patronize the brand for so long. Was the company right in being a part of this campaign?

Inchuai, R., Sukon, P. and Weerakhun, S. (2022). Molecular detection of *Chlamydia* spp. and risk factors in farmed Siamese crocodile in the mid-northeastern provincial cluster of Thailand. Veterinary Integrative Sciences 20(1): 231-245.

Abstract: This study surveyed the prevalence of chlamydial infection among farms in the mid-northeastern provincial cluster of Thailand by PCR and phylogenetic analyses of the sequences. Samples from 94 crocodiles were collected from 17 farms in five provinces together with farm management data. Chlamydiaceae was found in 48.94% of the samples (46/94). Of the 17 pooled samples analyzed using 16S rRNA sequencing, four samples exhibited 99.3 to 99.5% nucleotide identity with *Chlamydia psittaci*, three samples exhibited 99.1 to 99.3% nucleotide identity with *C. crocodili*, and one sample exhibited similarity to both species. The risk factors related to chlamydial infection included the source of young crocodiles and the frequency of water changes. Chlamydial infection was higher in nonclinical crocodiles than in clinical or dead crocodiles (P=

0.003). Pharyngitis, fibrinous pharyngitis, hepatitis, pneumonia, and hydropericardium were commonly found in chlamydial-positive cases of ill or dead crocodiles. *C. psittaci* and *C. crocodili* were found in both clinical and nonclinical crocodiles. *C. psittaci* is a well-known zoonotic pathogen. *C. crocodili* is a new species found in Siamese crocodiles in Thailand. In conclusion, the source of young crocodiles and frequency of water changes were identified as risk factors for chlamydial infection in crocodile farms. *C. crocodili* should be further investigated to better understand its implications for crocodile heath.

Desai, B., Mukherjee, S., Whitaker, N. and Ghosal, R. (2022). Anecdotal observations of 'double clutching' behaviour in captive Mugger crocodiles (*Crocodylus palustris*). Behaviour (https://doi.org/10.1163/1568539X-bja10153).

Abstract: Animals modulate their behaviours in accordance with their local environment and in the process, undergo different behavioural and physiological adaptations to better survive in a given ecosystem. One such behaviour that plays an important role in survival and sustenance of a species is the breeding behaviour. In this article, we present anecdotal information on breeding strategies of Marsh or Mugger crocodiles. Mugger crocodiles mostly lay single clutch during a year and have an elongated courtship and mating period lasting for 3-4 months. However, we show anecdotal data covering a period of 2 years for a Mugger crocodile producing double clutches annually under captive conditions. The laying of multiple clutches in captive Mugger crocodiles may indicate higher nutritional status and/or breeding strategies of the females under resourceful conditions. We suggest the need for future work on understanding proximate mechanisms underlying the 'double clutching' behaviour of Mugger crocodiles.

Balavand, A. (2022). Crocodile hunting strategy (CHS): a comparative study using benchmark functions. Iranian Journal of Numerical Analysis and Optimization (doi: 10.22067/IJNAO.2022.71418.1049).

Abstract: The crocodiles have a good strategy for hunting the fishes in nature. These creatures are divided into two groups of chasers and ambushers when they are hunting. The chasers direct prey toward shallow water with a powerful splash of its tail without catching them and the ambushers wait in the shallow and try to snatch the fishes. Such behavior inspires the development of a new population-based optimization algorithm called the crocodile hunting strategy (CHS). In order to verify the performance of the CHS, several classical benchmark functions and four constrained engineering design optimization problems are used. In the classical benchmark function, the comparisons are performed using Ant Colony Optimization (ACO), Differential Evolution (DE), Genetic Algorithm (GA), and Particle Swarm Optimization (PSO). Constrained engineering design problems are compared with Firefly Algorithm (FA), Harmony Search (HS), Shuffled Frog-Leaping Algorithm (SFLA), and Teaching-Learning-Based Optimization (TLBO). The results of the comparison show that different operators designed in the CHS algorithm lead to fast algorithm convergence and show better results compared to other algorithms.

Gani, M.I.Z.A., Hassan, R., Tisen, O.B. and Ahmad, R. (2022). Human-Crocodile Conflicts in Sarawak, Malaysian Borneo: An analysis of crocodile attacks from 2000 until 2020. International Journal of Biology and Biomedical Engineering 16 (doi: 10.46300/91011.2022.16.25).

Abstract: Crocodiles have caused a relatively high number of fatalities towards local people in Sarawak, a Malaysian state in Borneo. However, they have important cultural values and are well respected by the riverine communities in the state. The objective of this study is to determine the patterns of human-crocodile conflict in Sarawak which could help in managing the problems between crocodile and human. Information on crocodile attacks were collected from multiple sources including records kept by local authority, media or CrocBITE database. Over a 21-year period (2000-2020), the record attacks (n= 164) showed a balance between fatal and non-fatal cases. Most common victims in Sarawak were male (86.6%) and adults from the age of 31 to 40 years old (20.7%). The attacks occurred more during the daylight (59.4%), with the peak time for crocodile attacks was approximately between 1800 to 2359 hours (33.3%). Crocodile attacks occur slightly more during the wet season, from October to March (54.0%), with the highest one recorded in March (16.8%). Fishing (26.2%) and bathing (22.0%) in the rivers possess the highest risk of crocodile attack, suggesting that crocodiles are more likely to attack when the victim is in the water. The findings imply that crocodiles' attack pattern in Sarawak is associated with the people's activities pattern. There is a need to update the database on crocodile attacks in Sarawak on -real time basis as this will facilitate the relevant agencies in formulating the strategies to reduce the number of crocodile attacks and ensuring the safety of the riverine communities.

Darlim, G., Lee, M.S.Y., Walter, J. and Rabi, M. (2022). The impact of molecular data on the phylogenetic position of the putative oldest crown crocodilian and the age of the clade. Biology Letters 18: 20210603 (https://doi.org/10.1098/rsbl.2021.0603).

Abstract: The use of molecular data for living groups is vital for interpreting fossils, especially when morphology-only analyses retrieve problematic phylogenies for living forms. These topological discrepancies impact on the inferred phylogenetic position of many fossil taxa. In Crocodylia, morphology-based phylogenetic inferences differ fundamentally in placing *Gavialis* basal to all other living forms, whereas molecular data consistently unite it with crocodylids. The Cenomanian *Portugalosuchus azenhae* was recently described as the oldest crown crocodilian, with affinities to *Gavialis*, based on morphology-only analyses, thus representing a potentially important new molecular clock calibration. Here, we performed analyses incorporating DNA data into these morphological datasets, using scaffold and supermatrix (total evidence) approaches, in order to evaluate the position of basal crocodylians, including *Portugalosuchus*. Our analyses incorporating DNA data robustly recovered *Portugalosuchus* outside Crocodylia (as well as thoracosaurs, planocraniids and *Borealosuchus* spp.), questioning the status of *Portugalosuchus* as crown crocodilian and any future use as a node calibration in molecular clock studies. Finally, we discuss the impact of ambiguous fossil calibration and how, with the increasing size of phylogenomic datasets, the molecular scaffold might be an efficient (though imperfect) approximation of more rigorous but demanding supermatrix analyses.

Molinaro, H.G., Anderson, G.S., Gruny, L., Sperou, E.S. and Heard, D.J. (2022). Use of blood lactate in assessment of manual capture techniques of zoo-housed crocodilians. Animals 12: 397.

Abstract: Species-specific welfare indicators are important in promoting positive welfare for zoo animals. Reptiles are a notoriously understudied group in regards to behavior, welfare needs, and husbandry requirements. Using opportunistically obtained samples, we evaluated how blood lactate is affected by variation in manual capture and restraint in crocodilians. Lactate is an indicator of anerobic metabolism in reptiles. It offers a relatively simple and indirect way to assess physiological stress. Determining the best way to reduce struggling during capture and associated stress is of great importance to these species' overall welfare. Blood samples (N= 53) were collected from 10 different species of crocodilians. It was found that age class was a significant predictor variable of lactate levels after capture, and longer handling time seemed to cause an increase in lactate. Finally, draining enclosure pools for a small number of the captures was associated with higher lactate levels compared to other capture factors that were recorded.

This study showed that welfare of captive crocodilians could be improved by shortening the duration of physical restraint events when possible. Developing objective measures of welfare and establishing baseline recommendations for care and handling of crocodilians will ultimately promote and improve their wellbeing, along with that of other understudied reptiles in zoos.

Alston, B.M., Rainwater, T.R., Parrott, B.B., Wilkinson, P.M., Bowden, J.A. and Rice, C.D. (2022). Quantifying circulating IgY antibody responses against select opportunistic bacterial pathogens and correlations with body condition factors in wild American alligators, *Alligator mississippiensis*. Animals 11: 269.

Abstract: Little is known about the disease ecology of American alligators (*Alligator mississippiensis*), and especially how they respond immunologically to emerging infectious diseases and zoonotic pathogens. In this study, we examined serum samples collected from wild alligators in Florida (2010-2011) and South Carolina (2011-2012, 2014-2017) for antibody responses to multiple bacteria. Immunoglobulin Y (IgY) was purified from serum to generate a mouse monoclonal antibody (mAb AMY-9) specific to the IgY heavy chain. An indirect ELISA was then developed for quantifying antibody responses against whole cell *Escherichia coli*, *Vibrio parahaemolyticus*, *Vibrio vulnificus*, *Mycobacterium fortuitum*, *Erysipelothrix rhusiopthiae*, and *Streptococcus agalactiae*. In Florida samples the primary differences in antibody levels were between January-March and late spring through summer and early fall (May-October), most likely reflecting seasonal influences in immune responses. Of note, differences over the months in antibody responses were confined to *M. fortuitum*, *E. rhusiopthiae*, *V. vulnificus* and *E. coli*. Robust antibody responses in SC samples were observed in 2011, 2014, and 2015 against each bacterium except *E. coli*. All antibody responses were low in 2016 and 2017. Some of the highest antibody responses were against *V. parahaemolyticus*, *M. fortuitum* and *E. rhusiopthia*e. One SC alligator estimated to be 70+ years old exhibited the highest measured antibody response against *V. parahaemolyticus* and *M. fortuitum*. By combining data from both sites, we show a clear correlation between body-mass-indices (BMI) and antibody titers in all six of the bacteria examined. Our study provides a critical antibody reagent and a proof-of-concept approach for studying the disease ecology of alligators in both the wild and in captivity.

Sarathi, D., Ganapathy, D.K. and Sasanka, L.K. (2022). Knowledge, awareness, and prevalence of herpetophobia among dental students a a questionnaire study. Turkish Journal of Physiotherapy and Rehabilitation 32(2): 5827-5837.

Abstract: Phobia is defined as an unrealistic fear of an object, animal, activity or situations. It is a kind of anxiety disorder. People with phobia try to avoid things which trigger their fear and bring panic attacks. Among the fear of animals Herpetophobia is said to be fear of reptiles especially snakes, crocodiles, alligators, etc. A google form was created and 112 students of Saveetha Dental College and Hospitals, Poonamallee, Chennai-77 have answered the google forms. The statistical analysis was done using SPSS software version 23. Also Pearson chi square test was done to assess fear among dental students among the participants p-value <0.05 was considered to be significant. The google forms were evaluated using SPSS software version 23 and is found that 56 males and 56 females have attended the online survey. In a total student population 51.79% of students fear seeing reptiles, 33.04% of students do not fear seeing the reptile and 15.18% of students fear seeing reptiles. The study proved that the majority of the students do not suffer from herpetophobia.

Haase, B. (2022). "Reptiles are Here for Good": Ambivalent Perceptions of Exotic Leather in European Fashion of the 1920s and 1930s. Apparence(s) 11 (https://doi.org/10.4000/apparences.3831).

Abstract: Reptile skins have been sought-after materials for fashionable accessories for the last two centuries at least. This article traces the trend from its historical roots to the present day, with a special focus on the 1920s and 1930s, when "exotic leather" was in particularly high demand for ladies' shoes, bags, belts, etc. Dependent on technical innovations and economic conditions, the development of "reptile fashion" was determined by complex cultural phenomena where orientalism played a significant part. The perception of the material, often connoted as "strange" or "different", was deeply ambivalent: it oscillated between attraction and rejection, between allure and disgust, between seduction and indignation. Accessories made from the skins of snakes, crocodiles, lizards and other exotic species have been imbued with the ambivalence that surrounded the living animals - an ambivalence shaped by ancient mythology and superstition. On the one hand they are appealing, tempting and attractive, on the other they are repulsive, offensive or even menacing. Aesthetics, ethics and symbolics all combine in shaping our perceptions of these animals and their skins - then just as now. Today's discussions on the topic seem very much dominated by contemporary ethical considerations centered on the question of cruelty to animals, environmental destruction and ideological as well as economic colonialism. These aspects however were already present in earlier considerations. Despite long standing debates and criticisms the enduring fascination for reptile skins and their associated exoticism, rarity and sensuality still exists today as we can see in contemporary fashion shows. By means of a material culture approach - using images, written sources and extant objects - the article sketches several interdependent layers of perception within the field of aesthetics and ethics. Touching on current issues of sustainability, animal well-being and colonialism, the article highlights subjects such as orientalism, exotism and gender constructions within the realm of fashion history.

Hugosson, A. (2022). Snakes' commodification within the fashion system. Insights from animal ethics. Apparence(s) (https://doi.org/10.4000/apparences.3881).

Abstract: In the early 2000s a snake would appear as a prop in a live music performance, catalyzing a "trend" of live snakes as accessories which persists today on runways, red carpets, and on pages of fashion magazines. Around the same time, luxury fashion brands were selling out of snakeskin clothing and accessories, a trend which maintains popularity today. This paper applies a critical animal studies lens and insights from snake behavior literature to consider how live snakes are used in fashion performances and how they may be stressed by these environments. This article also discusses snakeskin as a distinct form of accessory which glamorizes and appraises snake death. Whether they appear alive or dead, the snake's nonconsensual appearance on a runway, red carpet, or stage as a superfluous accessory trivializes and passivizes the snake. Surprisingly, such arguments find opposition from influential global conservation organizations, and the role of the luxury fashion industry is a controversial talking point in snake conservation.

White, M.A., Bell, P.R., Campione, N.E., Sansalone, G., Brougham, T., Bevitt, J.J., Molnar, R.E., Cook, A.G., Wroe, S. and Elliott, D.A. (2022). Abdominal contents reveal Cretaceous crocodyliforms ate dinosaurs. Gondwana Research (https://doi.org/10.1016/j.gr.2022.01.016).

Abstract: Crocodylians are among Earth's most successful hypercarnivores, with their crocodyliform ancestors persisting since the Triassic. The diets of extinct crocodyliforms are typically inferred from distinctive bite-marks on fossil bone, which indicate that some species fed on contemporaneous dinosaurs. Nevertheless, the most direct dietary evidence (i.e. preserved gut contents) of these interactions in fossil crocodyliforms has been elusive. Here we report on a new crocodyliform, *Confractosuchus sauroktonos* gen. et sp. nov., from the Cenomanian (92.5-104 Ma) of Australia, with exceptionally preserved abdominal contents comprising parts of a

juvenile ornithopod dinosaur. A phylogenetic analysis recovered *Confractosuchus* as the sister taxon to a clade comprising susisuchids and hylaeochampsids. The ornithopod remains displayed clear evidence of oral processing, carcass reduction (dismemberment) and bone fragmentation, which are diagnostic hallmarks of some modern crocodylian feeding behaviour. Nevertheless, a macro-generalist feeding strategy for *Confractosuchus* similar to extant crocodylians is supported by a morphometric analysis of the skull and reveals that dietary versatility accompanied the modular assembly of the modern crocodylian *bauplan*. Of further interest, these ornithopod bones represent the first skeletal remains of the group from the Winton Formation, previously only known from shed teeth and tracks, and may represent a novel taxon.

Gatto, C.R. and Reina, R.D. (2022). A review of the effects of incubation conditions on hatchling phenotypes in non-squamate reptiles. Journal of Comparative Physiology B (https://doi.org/10.1007/s00360-021-01415-4).

Abstract: Developing embryos of oviparous reptiles show substantial plasticity in their responses to environmental conditions during incubation, which can include altered sex ratios, morphology, locomotor performance and hatching success. While recent research and reviews have focused on temperature during incubation, emerging evidence suggests other environmental variables are also important in determining hatchling phenotypes. Understanding how the external environment influences development is important for species management and requires identifying how environmental variables exert their effects individually, and how they interact to affect developing embryos. To address this knowledge gap, we review the literature on phenotypic responses in oviparous non-squamate (ie turtles, crocodilians and tuataras) reptile hatchlings to temperature, moisture, oxygen concentration and salinity. We examine how these variables influence one another and consider how changes in each variable alters incubation conditions and thus, hatchling phenotypes. We explore how incubation conditions drive variation in hatchling phenotypes and influence adult populations. Finally, we highlight knowledge gaps and suggest future research directions.

Gatesy, S.M., Manafzadeh, A.R., Bishop, P.J., Turner, M.L., Kambic, R.E., Cuff, A.R. and Hutchinson, J.R. (2022). A proposed standard for quantifying 3-D hindlimb joint poses in living and extinct archosaurs. Journal of Anatomy (doi: 10.1111/joa.13635).

Abstract: The last common ancestor of birds and crocodylians plus all of its descendants (clade Archosauria) dominated terrestrial Mesozoic ecosystems, giving rise to disparate body plans, sizes, and modes of locomotion. As in the fields of vertebrate morphology and paleontology more generally, studies of archosaur skeletal structure have come to depend on tools for acquiring, measuring, and exploring three-dimensional (3-D) digital models. Such models, in turn, form the basis for many analyses of musculoskeletal function. A set of shared conventions for describing 3-D pose (joint or limb configuration) and 3-D kinematics (change in pose through time) is essential for fostering comparison of posture/movement among such varied species, as well as for maximizing communication among scientists. Following researchers in human biomechanics, we propose a standard methodological approach for measuring the relative position and orientation of the major segments of the archosaur pelvis and hindlimb in 3-D. We describe the construction of anatomical and joint coordinate systems using the extant guineafowl and alligator as examples. Our new standards are then applied to three extinct taxa sampled from the wider range of morphological, postural, and kinematic variation that has arisen across >250 million years of archosaur evolution. These proposed conventions, and the founding principles upon which they are based, can also serve as starting points for measuring poses between elements within a hindlimb segment, for establishing coordinate systems in the forelimb and axial skeleton, or for applying our archosaurian system more broadly to different vertebrate clades.

Cost, I.N., Sellers, K.C., Rozin, R.E., Spates, A.T., Middleton, K.M. and Holliday, C.M. (2022). 2D and 3D visualizations of archosaur jaw muscle mechanics, ontogeny and phylogeny using ternary diagrams and 3D modeling. Journal of Experimental Biology (doi: 10.1242/jeb.243216).

Abstract: Comparing patterns of performance and kinematics across behavior, development and phylogeny is crucial to understand the evolution of complex musculoskeletal systems such as the feeding apparatus. However, conveying 3D spatial data of muscle orientation throughout a feeding cycle, ontogenetic pathway or phylogenetic lineage is essential to understanding the function and evolution of the skull in vertebrates. Here, we detail the use of ternary plots for displaying and comparing the 3D orientation of muscle data. First, we illustrate changes in 3D jaw muscle resultants during jaw closing taxa the American alligator (*Alligator mississippiensis*). Second, we show changes in 3D muscle resultants of jaw muscles across an ontogenetic series of alligators. Third, we compare 3D resultants of jaw muscles of avian-line dinosaurs, including extant (*Struthio camelus*, *Gallus gallus*, *Psittacus erithacus*) and extinct (*Tyrannosaurus rex*) species to outline the reorganization of jaw muscles that occurred along the line to modern birds. Finally, we compare 3D resultants of jaw muscles of the hard-biting species in our sample (*A. mississippiensis*, *T. rex*, *P. erithacus*) to illustrate how disparate jaw muscle resultants are employed in convergent behaviors in archosaurs. Our findings show that these visualizations of 3D components of jaw muscles are immensely helpful towards identifying patterns of cranial performance, growth and diversity. These tools will prove useful for testing other hypotheses in functional morphology, comparative biomechanics, ecomorphology and organismal evolution.

Talati, N., Kumar, R.N., Tuteja, D. and Kumar, N. (2022). Ongoing assessment of the Marsh crocodile (*Crocodylus palustris*) population in the wetlands of Anand and Kheda Districts, Gujarat, India. Reptiles & Amphibians 29: 103-106.

Rao, G.K.B.S.C., Waziri, S., Nielsen, A.E.V., Schwartz, F. and Mortensen, J.F. (2022). Crocodile bites. Ugeskr Laeger 184(6): V06210504. (in Danish).

Abstract: Crocodile bites are one of the most powerful bites of any creature. Bite wounds are usually deep, with severe tissue damage, frequently contaminated with unusual microorganisms, and are difficult to treat. This case report describes the treatment of a middle-aged man admitted after a crocodile attack to the left distal end of humerus, elbow and proximal forearm. He was successfully treated with empirical broad-spectrum antibiotics and repeated wound debridement. The patient was discharged after nine days of intensive care at a level 1 trauma unit, good outcomes were seen 8 months later.

Puértolas-Pascual, E., Serrano-Martínez, A., Pérez-Pueyo, M., Bádenas, B. and Canudo, J.I. (2022). New data on the neuroanatomy of basal eusuchian crocodylomorphs (Allodaposuchidae) from the Upper Cretaceous of Spain. Cretaceous Research (https://doi.org/10.1016/j.cretres.2022.105170).

Abstract: The South Pyrenean Basin (northeast Spain) has yielded a rich and diverse collection of vertebrate fossil remains from the uppermost Cretaceous (upper Maastrichtian), amongst which Crocodylomorpha is one of the best represented clades. This record includes remains of the last representatives of the basal eusuchian clade Allodaposuchidae prior to its disappearance after the Cretaceous-Paleogene (K/Pg) extinction event. In this context, the holotype skulls of the allodaposuchids *Arenysuchus*

gascabadiolorum and *Agaresuchus subjuniperus* were CT scanned to obtain the three-dimensional reconstruction of their inner cranial cavities, including the brain, nerves, blood vessels, paratympanic sinus system, and the paranasal sinuses. These cavities were compared with those of other crocodylomorphs, with special emphasis on other allodaposuchids and related clades such as Crocodylia. The endocranial anatomy of both taxa is consistent with their phylogenetic position as basal eusuchians, showing morphologies and neurosensorial and cognitive capabilities similar to those present in other allodaposuchids. Their inferred sensorial capabilities, such as an acute sense of olfaction and relatively good sight, fall within the range observed in most eusuchians and the crown group Crocodylia, suggesting that the sensory and cognitive skills observed in extant crocodylians were already similar at the end of the Mesozoic. Thanks to this study, all the known genera of Allodaposuchidae now have reconstructions of their inner skull cavities, making this clade one of the neuroanatomically best-studied groups among Neosuchia, providing valuable information on the neurological and neurosensorial evolution of the basal eusuchians and the early radiation of Crocodylia.

Polet, D.T. and Hutchinson, J.R. (2022). Estimating gaits of an ancient crocodile-line archosaur through trajectory optimization, with comparison to fossil trackways. Frontiers in Bioengineering and Biotechnology (doi: 10.3389/fbioe.2021.800311).

Abstract: Fossil trackways provide a glimpse into the behavior of extinct animals. However, while providing information of the trackmaker size, stride, and even speed, the actual gait of the organism can be ambiguous. This is especially true of quadrupedal animals, where disparate gaits can have similar trackway patterns. Here, predictive simulation using trajectory optimization can help distinguish gaits used by trackmakers. First, we demonstrated that a planar, five-link quadrupedal biomechanical model can generate the qualitative trackway patterns made by domestic dogs, although a systematic error emerges in the track phase (relative distance between ipsilateral pes and manus prints). Next, we used trackway dimensions as inputs to a model of *Batrachotomus kupferzellensis*, a long-limbed, crocodile-line archosaur (clade Pseudosuchia) from the Middle Triassic of Germany. We found energetically optimal gaits and compared their predicted track phases to those of fossil trackways of *Isochirotherium* and *Brachychirotherium*. The optimal results agree with trackways at slow speeds but differ at faster speeds. However, all simulations point to a gait transition around a non-dimensional speed of 0.4 and another at 1.0. The trackways likewise exhibit stark differences in the track phase at these speeds. In all cases, including when simulations are constrained to the fossil track phase, the optimal simulations after the first gait transition do not correspond to a trot, as often used by living crocodiles. Instead, they are a diagonal sequence gait similar to the slow tölt of Icelandic horses. This is the first evidence that extinct pseudosuchians may have exhibited different gaits than their modern relatives and of a gait transition in an extinct pseudosuchian. The results of this analysis highlight areas where the models can be improved to generate more reliable predictions for fossil data while also showcasing how simple models can generate insights about the behavior of extinct animals.

Masrour, M., Boutakiout, M., Herrero Gascón, J., Ochoa Martínez, R., Sáinz Ruiz de Zuazu, J.L. and Pérez Lorente, F. (2021). Crocodile tail traces and dinosaur footprints. Bathonian?- Callovian. Imilchil. High Central Atlas. Morocco. Geogaceta 69: 95-98.

Abstract: Three types of ichnites from a new site discovered in Imilchil were studied and described. The structures of pes and manus prints and tail traces of tetrapods provide data to separate: real ichnites (theropod footprints and crocodile tail drag marks); and sauropod' subtraces. Most of the theropod footprints are deformed by collapse of their walls, the sauropod subtraces show the strong deformation of about 10 well-stratified sedimentary levels. The surface on which we can see theropod and crocodile ichnites is the tracking surface, ie the original surface on which they were printed.

Jarić, I., Roll, U., Bonaiuto, M., Brook, B.W., Courchamp, F., Firth, J.A., Gaston, K.J., Heger, T., Jeschke, J.M., Ladle, R.J., Meinard, Y., Roberts, D.L., Sherren, K., Soga, M., Soriano-Redondo, A., Veríssimo, D. and Correia, R.A. (2022). Societal extinction of species. Trends in Ecology & Evolution (https://doi.org/10.1016/j.tree.2021.12.011).

Abstract: The ongoing global biodiversity crisis not only involves biological extinctions, but also the loss of experience and the gradual fading of cultural knowledge and collective memory of species. We refer to this phenomenon as 'societal extinction of species' and apply it to both extinct and extant taxa. We describe the underlying concepts as well as the mechanisms and factors that affect this process, discuss its main implications, and identify mitigation measures. Societal extinction is cognitively intractable, but it is tied to biological extinction and thus has important consequences for conservation policy and management. It affects societal perceptions of the severity of anthropogenic impacts and of true extinction rates, erodes societal support for conservation efforts, and causes the loss of cultural heritage.

Morris, Z.S., Vliet, K.A., Abzhanov, A. and Pierce, S.E. (2022). Developmental origins of the crocodylian skull table and platyrostral face. The Anatomical Record (doi: 10.1002/ar.24802).

Abstract: The dorsoventrally flattened skull typifies extant Crocodylia perhaps more than any other anatomical feature and is generally considered an adaptation for semi-aquatic feeding. Although the evolutionary origins of caniofacial flattening have been extensively studied, the developmental origins have yet to be explored. To understand how the skull table and platyrostral snout develop, we quantified embryonic development and post-hatching growth (ontogeny) of the crocodylian skull in lateral view using geometric morphometrics. Our dataset (n= 103) includes all but one extant genus and all of the major ecomorphs, including the extremely slender-snouted *Gavialis* and *Tomistoma*. Our analysis reveals that the embryonic development of the flattened skull is remarkably similar across ecomorphs, including the presence of a conserved initial embryonic skull shape, similar to prior analysis of dorsal snout shape. Although differences during posthatching ontogeny are recovered among ecomorphs, embryonic patterns are not distinct, revealing an important shift in developmental rate near hatching. In particular, the flattened skull table is achieved by the end of embryonic development with no changes after hatching. Further, the rotation of skull roof and facial bones during development is critical for the stereotypical flatness of the crocodylian skull. Our results suggest selection on hatchling performance and constraints on embryonic skull shape may have been important in this pattern of developmental conservation. The appearance of aspects of cranial flatness among Jurassic stem crocodylians suggests key aspects of these cranial developmental patterns may have been conserved for over 200 million years.

Wei, W., Li, T., Yao, B., Fan, G., Zhang, H., Pan, T., Lee, P., Nie, H., Yan, P., Xu, J. and Wu, X. (2022). The reproductive characteristics of the first-generation hybrid derived from three introduced purebred crocodile species. Current Herpetology (https://doi.org/10.5358/hsj.41.101).

Abstract: The objective of the present study was to explore the reproductive characteristics of the first-generation hybrid crocodile derived from captive *Crocodylus siamensis*, *C. niloticus* and *C. porosus* introduced from Cambodia, South Africa, and Malaysia. The data for 789 eggs and 651 hatchlings in 26 nests of hybrids of three different crocodile species were collected. Statistical analysis of reproductive variables of hybrid crocodile eggs indicated that the characteristic variables were normally distributed except

for the hatching rate. Regression analyses were used to develop the linear equation between egg length, egg width, hatching rate, hatchling weight, and egg mass. The results found a significant correlation between egg mass and other traits except for egg shape index. Significant influences of egg mass and the egg shape index on hatching rate were detected. There was no significant linear relationship between clutch size and egg characteristics. There were several differences in the reproductive characteristic variables between hybrid crocodiles of *C. niloticus* × *C. siamensis* and their parental species bred in captivity (variables of the hybrid were generally smaller) and between *C. siamensis* × *C. porosus* and their parental species (variables of the hybrid were generally larger). However, there was no difference in the reproductive variables between hybrid crocodiles of *C. niloticus* × *C. porosus* and their parental species. These results indicate that careful and rigorous scientific assessments are required on the hybridization of endangered species in particular to fully consider the effects of human intervention on hybridization.

Bona, P., Fernandez Blanco, M.V., Ezcurra, M.D., Belén von Baczko, M., Desojo, J.B. and Pol, D. (2022). On the homology of crocodylian post-dentary bones and their macroevolution throughout Pseudosuchia. The Anatomical Record (https://doi.org/10.1002/ar.24873).

Abstract: The lower jaw of early tetrapods is composed of several intramembranous ossifications. However, a tendency toward the independent reduction of the number of bones has been observed in the mandible of mammals, lepidosaurs, turtles, crocodiles, and birds. Regarding archosaurs, the coronoid and prearticular bones are interpreted to be lost during the evolution of stem-birds and stem-crocodiles, respectively, but the homology of the post-dentary bones retained in living pseudosuchians remains unclear. Here, we combine paleontological and embryological evidence to explore in detail the homology of the crocodylian post-dentary bones. We study the mandible embryogenesis on a sample of 71 embryos of *Caiman* and compare this pattern with the mandibular transformations observed across pseudosuchian evolution. In the pre-hatching ontogeny of caimans, at least five intramembranous ossification centers are formed along the margins of the internal mandibular fenestra (perifenestral centers) and, subsequently, merge to form the coronoid (three intramembranous centers), angular (one intramembranous center), and articular (one intramembranous and one chondral center). In the fossil record, an independent prearticular is lost around the base of Mesoeucrocodylia (optimized as reappearing in Thalattosuchia if they are placed within Neosuchia), and the coronoid is apomorphically lost in notosuchians. The integration of embryological and paleontological data indicates that most perifenestral centers are involved in the origin of the prearticular of non-mesoeucrocodylian pseudosuchians. These centers are rearranged during the evolution to contribute to different post-dentary bones in mesoeucrocodylians bolstering the idea that the coronoid and the articular of Crocodylia are not completely homologous to those of other diapsids.

Venczel, M., Sabau, I. and Codrea, V.A. (2021). Crocodylian remains from the late Paleocene of Jibou, Romania. Nymphaea XLVIII: 77-108.

Abstract. Here we report the presence of a planocraniid crocodyliform from the late Paleocene of Jibou (N-W Romania) representing one of the geologically earliest fossil records of this group from Europe. The recovered cranial and postcranial remains resulted probably from an attritional assemblage and may have belonged to a single planocraniid taxon. The morphological traits of this taxon (cf. *Boverisuchus*) include among others an interlocking occlusion in the premaxilla, a fl at cranial table with upturned orbital margins, a large exposure of the supraoccipital on the dorsal skull table, procoelous presacral vertebrae, keeled paramedian osteoderms lacking an anterior process, and mediolaterally compressed teeth possessing fine and irregularly distributed serrations on the mesiodistal carinae of the tooth crowns. The planocraniid crocodyliforms identified from the Paleocene of Romania mark an important paleogeographic link between the Chinese, European and North American occurrences. The lacustrine taphonomic context in the Jibou fossil locality is suggested by the presence of strictly limnic ostracods and gastropods, as well as other freshwater preferring groups including teleostei fishes and dortokid turtles. The planocraniid crocodyliforms might have acted as top predators in these freshwater habitats.

Ponce, D.A., Desojo, J.B. and Cerda, I.A. (2022). Palaeobiological inferences of the aetosaur *Aetosauroides scagliai* (Archosauria: Pseudosuchia) based on microstructural analyses of its appendicular bones. Historical Biology (https://doi.org/10.1080/08912963.2022.2035728).

Abstract: Aetosaurs were a group of armoured pseudosuchians, recorded in most of the Upper Triassic continental deposits worldwide. Several osteohistological contributions of aetosaurs focused on their osteoderms, but rarely on appendicular bones. Here, we analyse the microstructure of the humerus, femur and tibia of *Aetosauroides scagliai* (specimens PVL 2073 [holotype] and PVL 2052). These exhibit cortical bone formed by highly vascularised fibrolamellar bone present in the inner portion of the cortex, mixed with scarce parallel-fibred bone. Also, they show parallel-fibred bone in the outermost portion of the cortex. A general growth pattern that includes a first rapid stage followed by a slow stage is reported. Nevertheless, the growth rate and the presence of parallel-fibred bone embedded in fibrolamellar bone layers recognise more variation within Aetosauria. The value of appendicular bones and osteoderms as age estimators is variable, the first being useful in early stages, and in late stages the osteoderms are better (based on the particular growth of osteoderms). Through morphological (neurocentral sutures) and histological (EFS absent) information, the holotype (PVL 2073) was recovered between juvenile and subadult stages. Using a statistical model that combines microanatomical and morphological data, a terrestrial lifestyle is inferred for *Aetosauroides*, which concur with previous analyses.

Demuth, O.E., Wiseman, A.L.A., van Beesel, J., Mallison, H. and Hutchinson, J.R. (2022). Three-dimensional polygonal muscle modelling and line of action estimation in living and extinct taxa. Scientific Reports 12(1) (doi: 10.1038/s41598-022-07074-x).

Abstract: Biomechanical models and simulations of musculoskeletal function rely on accurate muscle parameters, such as muscle masses and lines of action, to estimate force production potential and moment arms. These parameters are often obtained through destructive techniques (ie dissection) in living taxa, frequently hindering the measurement of other relevant parameters from a single individual, thus making it necessary to combine multiple specimens and/or sources. Estimating these parameters in extinct taxa is even more challenging as soft tissues are rarely preserved in fossil taxa and the skeletal remains contain relatively little information about the size or exact path of a muscle. Here we describe a new protocol that facilitates the estimation of missing muscle parameters (ie muscle volume and path) for extant and extinct taxa. We created three-dimensional volumetric reconstructions for the hindlimb muscles of the extant Nile crocodile and extinct stem-archosaur Euparkeria, and the shoulder muscles of an extant gorilla to demonstrate the broad applicability of this methodology across living and extinct animal clades. Additionally, our method can be combined with surface geometry data digitally captured during dissection, thus facilitating downstream analyses. We evaluated the estimated muscle masses against physical measurements to test their accuracy in estimating missing parameters. Our estimated muscle masses generally compare favourably with segmented iodine-stained muscles and almost all fall within or close to the range of observed muscle masses, thus indicating that our estimates are reliable and the resulting lines of action calculated sufficiently accurately. This method has

potential for diverse applications in evolutionary morphology and biomechanics.

Benson, R.B.J., Godoy, P., Bronzati, M., Butler, R.J. and Gearty, W. (2022). Reconstructed evolutionary patterns for crocodile-line archosaurs demonstrate impact of failure to log-transform body size data. Communications Biology 5(1): 171 (doi: 10.1038/s42003-022-03071-y).

Stockdale, M.T. and Benton, M.J. (2022). Reply to: 'Reconstructed evolutionary patterns from crocodile-line archosaurs demonstrate the impact of failure to log-transform body size data'. Communications Biology 5(1):170 (doi: 10.1038/s42003-022-03072-x).

Dolan, J.K., Stacy, N.I., Lo, M., Ossiboff, R.J. and Lanier, C.J. (2022). What is your diagnosis? Blood film from a Yacare caiman (*Caiman yacare*). Veterinary Clinical Pathology (doi: 10.1111/vcp.13096).

Idani, M., N'guessan, E.K.Z., Millogo, M., Badini, S.P.A., Zango, A., Ili, B.V., Crezoit, G.E. and Konsem, T. (2022). Cranio-cervico-facial injuries due to crocodile bite: a rare observation in Yalgado Ouedraogo University Hospital (Burkina Faso). Journal of Oral Medicine and Oral Surgery 28(1) (https://doi.org/10.1051/mbcb/2021051).

Abstract: Human aggressions by wild animals are rare but often dramatic. Among the animals that attack humans, the crocodile is singled out by the impressive power of its jaws, which leave very little chance of survival to the victim it manages to grasp. Crocodile bite lesions most often affect the limbs and trunk. Cephalic injuries are exceptional and particularly serious because of the important infectious risks and their usual mortality. The authors report a case of cranio-cervico-facial trauma due to a crocodile bite in a 16-year-old patient with deep soft tissue wounds associated with a fracture of the mandible. Emergency management resulted in a favorable outcome. The report of this case aims to highlight the clinical specificities and the modalities of management of this rare lesion entity in an under medicalized context.

Singh, L.A.K., Sharma, R.K. and Pawar, U.R. (2022). Raptors observed (1983-2016) in Natonal Chambal Gharial Sanctuary: semi-arid biogeographic region suggestons for parametric studies on ecological contnuity in Khathiar-Gir Ecoregion, India. Journal of Threatened Taxa 14(1): 20444-20460.

Abstract: The birds of prey or raptors in the Natonal Chambal Sanctuary (NCS) assume importance as they are among the top predators of the region, predatng on small crocodilians, turtles, and birds. Our checklist of 30 species of raptors is developed from observations made during winter surveys conducted between 1983 and 2016. The study area covered the course of the Chambal River including its confuence with the Kuno River that leads from Palpur-Kuno Sanctuary in Madhya Pradesh. The raptors which use the steep and inaccessible mud cliffs of the Chambal landscape include Bonelli's Eagle *Aquila fasciata*, Laggar Falcon *Falco jugger*, Egyptan Vulture *Neophron percnopterus*, White-rumped Vulture *Gyps bengalensis*, Spoted Owlet *Athene brama* and the Indian Eagle-Owl or Rock Eagle Owl *Bubo bengalensis*. Most of the other raptors noted in NCS appear to visit from and around the adjoining wildlife areas of Rajasthan and Madhya Pradesh. According to two methods of classification the study comes in the semi-arid biogeographic zone or Khathiar-Gir dry deciduous forest ecoregion. The list of raptors from NCS-Kuno has been compared with previous reports and the list available for Sariska Tiger Reserve and Ranthambhore Tiger Reserve in Rajasthan. The present work is the outcome of a long-term ecological monitoring that primarily focused on the Gharial *Gavialis gangeticus* and its ecological associates in water and the riverine shores. The birds of prey demanded time and attention for looking above and away from the water surface or the shorelines. Yet, our meticulous records maintained over 34 years have generated a basal profile that is expected to inspire focused studies on parameters that sustain ecological association of raptors of NCS adjoining forest habitats and wildlife sanctuaries in the ecoregion.

Akat, E., Yenmiş, M., Pombal, M.A., Molist, P., Megías, M., Arman, S., Veselỳ, M., Anderson, R. and Ayaz, D. (2022). Comparison of vertebrate skin structure at Class level: A review. The Anatomical Record (https://doi.org/10.1002/ar.24908).

Abstract: The skin is a barrier between the internal and external environment of an organism. Depending on the species, it participates in multiple functions. The skin is the organ that holds the body together, covers and protects it, and provides communication with its environment. It is also the body's primary line of defense, especially for anamniotes. All vertebrates have multilayered skin composed of three main layers: the epidermis, the dermis, and the hypodermis. The vital mission of the integument in aquatic vertebrates is mucus secretion. Cornification began in apmhibians, improved in reptilians, and endured in avian and mammalian epidermis. The feather, the most ostentatious and functional structure of avian skin, evolved in the Mesozoic period. After the extinction of the dinosaurs, birds continued to diversify, followed by the enlargement, expansion, and diversification of mammals. Which brings us to the most complicated skin organization of mammals with differing glands, cells, physiological pathways, and the evolution of hair. Throughout these radical changes, some features were preserved among classes such as basic dermal structure, pigment cell types, basic coloration genetics, and similar sensory features which enable us to track the evolutionary path. The structural and physiological properties of the skin in all classes of vertebrates are presented. The purpose of this review is to go all the way back to the agnathans and follow the path step by step up to mammals to provide a comparative large and updated survey about vertebrate skin in terms of morphology, physiology, genetics, ecology, and immunology.

Kavková, M., Šulcová, M., Zikmund, T., Pyszko, M., Kaiser, J. and Buchtová, M. (2022). X-ray microtomography imaging of craniofacial hard tissues in selected reptile species with different types of dentition. Gigascience (doi: 10.1093/gigascience/giac016).

Abstract: Reptiles exhibit a large heterogeneity in teeth morphology. The main variability comprises the different tooth shape, the type of tooth attachment to the underlying bone, or the ability to replace the teeth. Here, we provide full datasets of microtomography scans and 3D models of reptilian dentitions and skulls. We selected representative species for each of 9 reptilian families on the basis of their characteristic dental features. Because there are ≥4 different types of tooth-bone attachments, ranging from the mammalian-like thecodont attachment found in crocodilians to the simple acrodont implantation observed in some lizards, we aimed to evaluate species with different types of tooth-bone attachments. Moreover, another interesting feature varying in reptilian species is the complexity of tooth shape or the number of tooth generations, which can be associated with the type of tooth attachment to the jawbone. Therefore, selected model species also include animals with distinct tooth morphology along the jaw or different number of tooth generations. The development of tooth attachment and relationship of the tooth to the jaw can be further analysed in detail on a large collection of pre-hatching stages of chameleon. Next, we introduce different possibilities for how these datasets can be further used to study tooth-bone relationships or tooth morphology in 3D space. Moreover, these datasets can be valuable for additional morphological and morphometric analyses of reptilian skulls or their individually segmented skeletal elements. Our collection of microcomputed tomography scans can bring new insight into dental or skeletal research. The broad selection of reptilian species,

together with their unique dental features and high quality of these scans including complete series of developmental stages of our model species and provide large opportunities for their reuse. Scans can be further used for virtual reality, 3D printing, or in education.

Brandt, L.A., Jennings, N.D., Squires, M.A., Hackett, C., Smith, C.D. and Mazzotti, F.J. (2022). Hematology and biochemistry reference intervals for American alligator (*Alligator mississippiensis*) in South Florida, USA. Journal of Wildlife Diseases (doi: 10.7589/JWD-D-21-00142).

Abstract: We calculated reference intervals for 48 blood parameters from 120 wild American alligators (*Alligator mississippiensis*) in South Florida, USA. Although previously reported by others, this study includes additional parameters not yet reported in wild populations. Most previously reported blood parameter values were similar to ours and fell within our reference intervals.

Das, U.K., Pradhan, R.K., Dash, A.P. and Panth, S. (2021). Study of habitat preference and conservation of Mugger Crocodile (Crocodylus palustris Lesson 1831) in Ghodahada Dam of Ganjam District, Odisha, India. International Educational Scientific Research Journal 7(7): 3-11.

Abstract: The Mugger crocodile (*Crocodylus palustris* Lesson 1831) in Ghodahada dam was broadly monitored and studied through the annual census operations in Berhampurforest division from 2005 to 2018. Direct sighting was achieved for adults and even through binoculars for hatchlings in the dam for population estimation. In different seasons habitat survey was done through river creek, island structures for nest detection. Total 55 numbers of Mugger crocodiles are recorded from 4 different sites in Ghodahada dam region. The largest crocodile is around 14 feet long and other 12 numbers more than 10 feet long mostly sighted in the creeks of the dam. The Juveniles are more (45%) followed by sub-adults (25%), adults (20%) and hatchlings or yearlings (10%). Age group is unknown for 10 individuals as they may have stunted growth or could not be accessed by enumerators.

Figueiredo, S.D., Cunha, P.P. and Carvalho, I.S. (2022). Marine mammals fossil remains and synthesis of the sedimentary and paleontological record of the Furninha Cave Pleistocene (Peniche, Portugal). Cuaternario y Geomorfología 36(1-2) (https://doi.org/10.17735/cyg.v36i1-2.89297).

Abstract: The Gruta da Furninha is a cave-site in Lower Jurassic limestones, of mainly marine genesis located at ~850 m SE of the Carvoeiro Cape, on the southern coast of the Peniche peninsula (central western mainland Portugal). The entrance of the gallery, situated in the middle of the cliff, is at ~15 m of altitude. This cave contained a rich and diverse fossiliferous set of Late Pleistocene vertebrates, distributed in several stratigraphic levels, currently housed at the Geological Museum of LNEG (Lisbon). The cave had a record of primitive human occupations documented by 106 Middle to Late Paleolithic artefacts, found in the lower lithostratigraphic unit (Pleistocene). It had also another human occupation in an upper unit (Neolithic, Holocene), where human skeleton elements and artefacts were found. This study focuses on two teeth previously identified as crocodile, housed in collections of the Geological Museum in the assemblages of the Furninha Cave and on a set of five bones, housed at Centro Português de Geo-História e Pré-História (CPGP) and collected in a marine terrace in the Furninha cliff. The occurrence of crocodile remains in the Upper Pleistocene of Portugal is not consistent with the fossil record of this period or with the environmental conditions associated with the fully marine paleoenvironments around Furninha Cave. A more detailed analysis of these teeth and their stratigraphic location now supports that they are cetacean teeth with ~80 ka, which is consistent with the fossil association, depositional environments and climate conditions of the Late Pleistocene in mainland Portugal. To add to these two teeth, five bones remains were found during the 2017 year sedimentary field work in the marine terraces on the Furninha Cave cliffs, at 4-7 m a.s.l. level , which could be carpal bones of marine mammals.

Anwised, P., Suttee, K., Mahakunakorn, P., Klaynongsruang, S. and Jangpromma, N. (2022). *Crocodylus siamensis* liver extracts exhibit antimicrobial activity and induce phagocytic activity in macrophage cells. Indian Journal of Pharmaceutical Sciences (doi: 10.36468/pharmaceutical-sciences.911).

Abstract: Antimicrobial peptides are documented as having a crucial role in innate immune response. Many reports have studied antimicrobial peptides from the crocodile. Thus, the antimicrobial activity of liver protein extract from *Crocodylus siamensis* was examined. Our results show that P50 and P80, partially purified crocodile liver protein extract at 45 mg/ml, can inhibit gram-positive bacteria with the highest percentages of inhibition at 48.22% and 37.54% respectively, while gram-negative bacteria could be inhibited at 47.31% and 35.32%, respectively. However, only P80 was selected for further phagocytosis activity investigation since it showed low cytotoxicity in the macrophage cell line. The results show that P80 can kill bacteria by an intracellular killing process in phagocytic cells of macrophages in a dose-dependent manner. Moreover, the internalization of phagocytosis activity of macrophages was assayed using fluorescein isothiocyanate-labeled *Escherichia coli* and flow cytometry. The results reveal that P80 can degrade bacteria by inducing phagosome formation in a time and dose-dependent manner (200-800 µg/ml). In these findings, the liver protein extract of *Crocodylus siamensis* had an enhancing effect on macrophage RAW 264.7 cells in the phagocytosis process.

Plint, A.G., Helm, C.W. and Lockley, M.G. (2022). Crocodylian and dinosaur trace fossil assemblages from crevasse splay/levee and floodplain lake environments: middle Cenomanian Dunvegan Formation, northeast British Columbia, Canada. Historical Biology (https://doi.org/10.1080/08912963.2022.2043294).

Abstract: Delta-plain strata of the Cenomanian Dunvegan Formation, in north-east British Columbia, represent anastomosed rivers that were flanked by vegetated crevasse splays, wetlands and shallow lakes. These rocks preserve a rich record of ankylosaur and ornithopod walking and wading tracks, as well as crocodylian swim traces and tracks. Analysis of depositional, erosional, and trace-making events reveals alternating phases of flooding and emergence that controlled both animal activity (walking, wading, swimming) and mud substrate consistency (firm vs. soupy), and hence fidelity of track preservation. Some tracks resemble those produced by both ankylosaurs and crocodylians, and confident attribution is difficult. The absence of tail drag marks suggests an ankylosaur trackmaker, whereas prominent claw marks might favour a crocodylian origin. Unusually large crocodylian swim traces suggest animals about 9 m, and possibly up to 12 m in length. These large traces may represent a precursor to the giant crocodylian *Deinosuchus*. Ankylosaur tracks are well-preserved in lake and channel-margin deposits, whereas crocodylian traces are most commonly preserved in firm muddy lake sediments that had experienced previous subaerial exposure and dewatering. Close integration of trace fossils with sedimentary and stratigraphic features makes it possible to reveal a detailed chronology of biotic and sedimentary events on palaeo-surfaces.

Georgalis, G.L. and Delfino, M. (2022). The fossil record of crocodylians (Reptilia: Crocodylia) in Greece. Pp. 237-243 *in* Fossil Vertebrates of Greece. Springer: Cham.

Abstract: The fossil record of crocodylians from Greece is reviewed herein. Currently absent from the extant herpetofauna of the country (and the whole Europe), however, fossil record attests that crocodylians were present, even if rare and poorly represented (only

isolated teeth and one osteoderm have been found so far) during the Miocene. The oldest crocodylian fossils are known from the early Miocene (?MN3) of Lesvos, with slightly younger finds also occurring in the early Miocene (MN4) of Euboea. The youngest record from the country is known from the late Miocene (MN9) of Crete, representing also the youngest record of crocodylians in the northeastern Mediterranean.

Rakotozandry, R., Ranivoharimanana, L., Ranaivosoa, V., Rasolofomanana, N., Hekkala, E. and Samonds, K.E. (2021). Description of the subfossil crocodylians from a new Late Pleistocene subfossil site (Tsaramody, Sambaina Basin) in central Madagascar. Malagasy Nature 15: 94-107.

Abstract: Madagascar is famous today not only for its unique biodiversity, but also for the high levels of endemism of plants and animals. Less appreciated is the fact that, in the recent past, the island had even greater biodiversity with many other endemic animals such as giant lemurs, elephant birds, pygmy hippopotami, tortoises, and crocodiles that have gone extinct within the past 2000 years. The extinction of many of these groups is thought to be the result of both human activities and environmental change. Most research has focused on the lemurs, hippopotami, and elephant birds. Other recently extinct animals, including the Malagasy horned crocodile (*Voay robustus*), are relatively poorly known. Madagascar's subfossil crocodylians include two taxa: the extinct *V. robustus* (the Malagasy horned crocodile) and the extant *Crocodylus niloticus*. The latter arrived on Madagascar relatively recently and we know little about the habitat preferences, distributions and ecological interactions (if any) of either species during the Holocene. In order to better understand the recent history of crocodylian extinction in Madagascar, we must first identify which species were present and where they were found. We present here a description of subfossil crocodylian material collected from the newly discovered subfossil site of Tsaramody (Sambaina Basin), a high-elevation wetland environment. At 1655 m, it represents the highest-elevation subfossil site on the island. Here we describe both cranial (eg premaxillary, jugal, and squamosal "horns") and postcranial elements (eg osteoderms). Our research indicates that crocodile material from Tsaramody appears morphologically to belong to *V. robustus*, the extinct species. However, oval tuberosities on the frontal bone and a triangular extension of the squamosal bone suggest previously unrecognized variation.

Iijima M, Qiao Y, Lin W, Peng Y, Yoneda M, Liu J. (2022). An intermediate crocodylian linking two extant gharials from the Bronze Age of China and its human-induced extinction. Proceedings of the Royal Society B 289: 20220085.

Abstract: A solid phylogenetic framework is the basis of biological studies, yet higher level relationships are still unresolved in some major vertebrate lineages. One such group is Crocodylia, where the branching pattern of three major families (Alligatoridae, Crocodylidae and Gavialidae) has been disputed over decades due to the uncertain relationship of two slender-snouted lineages, gavialines and tomistomines. Here, we report a bizarre crocodylian from the Bronze Age of China, which shows a mosaic of gavialine and tomistomine features across the skeleton, rendering support to their sister taxon relationship as molecular works have consistently postulated. Gavialine characters of the new Chinese crocodylian include a novel configuration of the pterygoid bulla, a vocal structure known in mature male Indian gharials. Extinct gavialines have repeatedly evolved potentially male-only acoustic apparatus of various shapes, illuminating the deep history of sexual selection on acoustic signalling in a slender-snouted group of crocodylians. Lastly, a cutmark analysis combined with accelerator mass spectrometry (AMS) radiocarbon dating of bone remains demonstrated that two individuals from Shang and Zhou dynasties in Guangdong, China, suffered head injuries and decapitation. Archaeological evidence together with historical accounts suggests the human-induced extinction of this unique crocodylian only a few hundred years ago.
Kelly, H. (2021). Molecular Investigation of Protozoa and Bacteria of Veterinary-Medical Importance from the Faeces of Captive Reptiles. Thesis, University of Veterinary Medicine, Budapest, Hungary.

Tellez, M., Brown, T.T. and Izaguirre, A. (2021). *Crocodylus acutus* (American Crocodile). Ectoparasitism. Herpetological Review 52(4): 850-851.

Buenfil-Rojas, A.M., Alvarez-Legorreta, T., González-Jáuregui, M., Rendón-von Osten, J. and Cedeño-Vazquez, J.R. (2022). Effectiveness of Morelet's crocodile as a bioindicator of metal pollution and metallothionein response to spatial variations of metal exposure. SSRN (http://dx.doi.org/10.2139/ssrn.4051087).

Abstract: Several studies have assessed the potential of crocodylians as bioindicators of environmental contamination. In this study, Morelet's crocodile (*Crocodylus moreletii*) was used as a bioindicator of metal pollution across five locations in southeastern Mexico classified as having high, medium, and low anthropogenic impact were sampled to assess *C. moreletii* as a bioindicator of metal pollution. Total length, weight and sex were determined for each animal and concentrations of metals and metallothioneins (MTs) were determined by using non-destructive tissues. Mercury (Hg) concentrations in crocodile blood and scutes generally exhibited a decreasing pattern from the higher impacted site to the lower impacted site (χ^2 (14)= 185.42, p<0.001), suggesting that concentrations in these samples are sensitive enough to identify difference in the bioavailability of Hg within crocodile populations. The highest concentrations were detected in scutes from Laguna Guerrero (Hg= 0.60 ± 0.217 μg/g w.w.) and Nichupté-Bojorquez (Cd= 14.99 ± 2.95 μg/g w.w., Cu= 58.66 ± 11.29 μg/g w.w., Zn= 80.86 ± 80.54 μg/g w.w.). MTs in blood plasma were detected at all sites (27.48 ± 4.78 μg/mL) but was low in erythrocytes detection frequency, suggesting this latter fraction may not be useful for MTs analysis. In general, our study supports the utility of crocodiles as bioindicators of xenobiotic metal pollution. However, it is necessary for such studies to perform assays for specific MT isoforms and the effective concentrations of metals bound to this protein, and to determine metal concentrations in multiple environmental matrices from the sites under evaluation.

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. SSRN (http://dx.doi.org/10.2139/ssrn.4055013).

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^{-1}). The incidence of Pb poisoning was higher in male crocodiles, with mean blood lead (BPb) levels in males (3780 ± 4690 ng ml^{-1}) significantly (p<0.001) higher compared to females (266 ± 230 ng ml^{-1}). Blood Pb levels were correlated with concentrations measured in tail fat tissue (n.d.-4175 ng g^{-1} wet wt). Although most of the crocodiles sampled appeared to be in good physical condition, highly elevated BPb levels (>6000 ng ml^{-1}) 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.

Gomes, L.G., Stocco, M.B., De Sousa, N.P., Martini, A.C., Morgado, T.O., Spiller, P.R., Moreira, L.F.B. and De Souza, R.L. (2021). Influence of incubation temperature and embryonic motility on the growth of members of *Caiman yacare* (Daudin, 1802). Brazilian Journal of Biology 84: e252845.

Abstract: This study aimed to evaluate whether skeletal development of the Pantanal Caiman (*Caiman yacare*) is similarly influenced by temperature variation and controlled increases in embryo motility. All eggs were incubated at 90% humidity and 29°C for the first 45 days. Thereafter, the incubation temperature was either maintained at 29°C and embryos were treated with 4-aminopyridine (4-AP) on days 46, 47, 48, and 49 (Group I, 29°C 4-AP, n= 15); maintained at 29°C (n= 14; Group II); or at 33°C (n= 14, Group III). Embryonic movement was measured using an Egg Buddy® digital monitor on days 30, 35, 42, 49, 56, and 60, at which point embryos were euthanized and samples were collected for analysis. No differences were observed between groups with varying incubation temperatures. In contrast, embryonic motility was greater in embryos treated with 4-AP ($P<0.001$) on day 49, and this was associated with higher proportions of snout-vent and hand lengths. This study demonstrates for the first time that pharmacologically induced increases in embryo motility result in phenotypic changes to the proportion of elements during prenatal ontogeny, thereby effectively altering the adaptation of the species to specific environments.

Gomes Tarlé, R. and Haddad Junior, V. (2022). Broad-Snouted caiman (*Caiman latirostris*) bite. Revista da Sociedade Brasileira de Medicina Tropical 55: e0655.

Bunmephiphit, C. and Sornsanit, P. (2022). Upgrading waste from crocodile mixed bamboo sawdust pellet. Life Sciences and Environment Journal 23(1): 208-218.

Abstract: Biomass pelleting process is the process of increasing the density of the biomass. It has higher values of the physical and chemical properties. This research used crocodile manure which is the waste from crocodile farms mixed with bamboo sawdust from local wicker crafts. The mixed crocodile-bamboo sawdust pellets can reduce the problem of smell and sludge of the crocodile farm and decrease the burning of bamboo sawdust. The results showed that, the crocodile manure mixed with bamboo sawdust pellets increased the density up to 875.70 kg/m^3 (moisture content 20%, ratio of crocodile manure and bamboo sawdust 1:0, 20CS10) The lower value chemical properties including moisture content, volatile matter and ash content were of 10.37%, 26.29% and 28.10%, respectively While the fixed carbon and calorific value were 34.19% and 13.85 mega joules/kg, respectively which were found to be high. It can be utilized as a fuel for generation. The crocodile manure mixed bamboo sawdust pellets can reduce environmental impacts such as smell and sludge in the crocodile farm. It is also the management process of quality crocodile farm. Moreover, it reduces the burning of biomass in the local.

Oda, F.H., Signorelli, L., De Souza, F.C., De Souza, V.C., De Oliveira Almeida, W., Pereira, L.N. and De Morais, A.R. (2022). *Drymarchon corais* (Colubridae) and *Caiman crocodilus* (Alligatoridae) use different feeding behaviors to consume poisonous toads. bioTROPICA (https://doi.org/10.1111/btp.13089).

Abstract: *Drymarchon corais* and *Caiman crocodilus* are reported here using different feeding behaviors for consuming poisonous toads of the genus *Rhinella* (Bufonidae). *Drymarchon corais* was observed feeding on specimens of *Rhinella diptycha* without avoiding contact with the parotoid macroglands, suggesting that this snake species is immune to toad toxins. *Caiman crocodilus* was recorded avoiding contact with the parotoid macroglands of specimens of *Rhinella marina* by consuming only the front and rear legs, suggesting that this caiman may be sensitive to toad toxins. Further experimental and field studies are needed to better understand the feeding behavior of *D. corais* and *C. crocodilus* and the effects of *Rhinella* toxins on these predators.

Larriera, A. (2022). Deontology or consequentialism? Ethical approach on the use and management of wildlife, illustrated by the use of caimans in Latin America. Ethnobiology and Conservation (doi:10.15451/cc2022-03-11.07-1-5).

Ingram, D.J., Prideaux, M., Hodgins, N.K., Frisch-Nwakanma, H., Avila, I.C., Collins, T., Cosentino, M., Keith-Diagne, L.W., Marsh, H., Shirley, M.H., Van Waerebeek, K., Djondo, M.K., Fukuda, Y., Glaus, K.B.J., Jabado, R.W., Lang, J.W., Lüber, S., Manolis, C., Webb, G.J.W. and Porter, L. (2022). Widespread use of migratory megafauna for aquatic wild meat in the tropics and subtropics. Frontiers in Marine Science (https://doi.org/10.3389/fmars.2022.837447).

Abstract: Wild animals are captured or taken opportunistically, and the meat, body parts, and/or eggs are consumed for local subsistence or used for traditional purposes to some extent across most of the world, particularly in the tropics and subtropics. The consumption of aquatic animals is widespread, in some places has been sustained for millennia, and can be an important source of nutrition, income, and cultural identity to communities. Yet, economic opportunities to exploit wildlife at higher levels have led to unsustainable exploitation of some species. In the literature, there has been limited focus on the exploitation of aquatic non-fish animals for food and other purposes. Understanding the scope and potential threat of aquatic wild meat exploitation is an important first step toward appropriate inclusion on the international policy and conservation management agenda. Here, we conduct a review of the literature, and present an overview of the contemporary use of aquatic megafauna (cetaceans, sirenians, chelonians, and crocodylians) in the global tropics and subtropics, for species listed on the Appendices of the Convention on the Conservation of Migratory Species of Wild Animals (CMS). We find that consumption of aquatic megafauna is widespread in coastal regions, although to varying degrees, and that some species are likely to be at risk from overexploitation, particularly riverine megafauna. Finally, we provide recommendations for CMS in the context of the mandate of the Aquatic Wild Meat Working Group.

Walsh, Z.C., Olson, H., Clendening, M. and Rycyk, A. (2022). Social behavior deficiencies in captive American alligators (*Alligator mississippiensis*). Journal of Zoological and Botanical Gardens 3(1): 131-146.

Abstract: Understanding how the behavior of captive American alligator (*Alligator mississippiensis*) congregations compares to wild congregations is essential to assessing the welfare of alligators in captivity. Wild alligator congregations perform complex social behaviors, but it is unknown if such behaviors occur in captive congregations as frequently. We observed the behaviors of a captive and wild congregation of American alligators in Florida, USA in January 2021. Social behaviors were, on average, 827% more frequent in the wild congregation than the captive, and the wild congregation had a richer repertoire of social behaviors, with growling and HOTA (head oblique tail arched) behaviors being particularly common.

High walking, a nonsocial behavior, dominated the behavioral repertoire of the captive congregation (94% of behaviors, excluding feeding) and may be a stereotypy that can be used as an indicator of welfare. Both congregations experienced human disturbance and displayed flushing as a species-specific defense reaction. Captive environments differ from the wild with respect to size, structure, stocking density, resource availability, and human presence. These differences translate into behavioral differences between wild and captive congregations. We identified important behavioral differences between wild and captive alligator congregations that can serve as a platform for more detailed investigations of alligator welfare in captivity.

Lemos Barão-Nóbrega J.A., González-Jaurégui, M. and Jehle, R. (2022). N-mixture models provide informative crocodile (*Crocodylus moreletii*) abundance estimates in dynamic environments. PeerJ 10: e12906.

Abstract: Estimates of animal abundance provide essential information for population ecological studies. However, the recording of individuals in the field can be challenging, and accurate estimates require analytical techniques which account for imperfect detection. Here, we quantify local abundances and overall population size of Morelet's crocodiles (*Crocodylus moreletii*) in the region of Calakmul (Campeche, Mexico), comparing traditional approaches for crocodylians (Minimum Population Size - MPS; King's Visible Fraction Method - VFM) with binomial N-mixture models based on Poisson, zero-inflated Poisson (ZIP) and negative binomial (NB) distributions. A total of 191 nocturnal spotlight surveys were conducted across 40 representative locations (hydrologically highly dynamic aquatic sites locally known as aguadas) over a period of 3 years (2017-2019). Local abundance estimates revealed a median of 1 both through MPS (min-max: 0-89; first and third quartiles, Q_1-Q_3: 0-7) and VFM (0-112; Q_1-Q_3: 0-9) non-hatchling *C. moreletii* for each aguada, respectively. The ZIP based N-mixture approach shown overall superior confidence over Poisson and NB, and revealed a median of 6 ± 3 individuals (min= 0; max= 120 ± 18; Q_1= 0; Q_3= 18 ± 4) jointly with higher detectabilities in drying aguadas with low and intermediate vegetation cover. Extrapolating these inferences across all waterbodies in the study area yielded an estimated ~10,000 (7000-11,000) *C. moreletii* present, highlighting Calakmul as an important region for this species. Because covariates enable insights into population responses to local environmental conditions, N-mixture models applied to spotlight count data result in particularly insightful estimates of crocodylian detection and abundance.

Devlin, S. and Ogle, B. (2022). Examining how a general audience rates herptile welfare in zoos. Journal of Zoo and Aquarium Research.

Abstract: There is a demonstrated lack of research available in the realm of herptile welfare and the public perception of zoo animal welfare. This study examined zoo visitor perceptions of herptile welfare through delivery of a survey at three different zoos with the goal to elucidate the specific factors that influence visitor perceptions. Findings from this study suggest that there is a correlation between the frequency of annual zoo visits and welfare perceptions. There was an observed difference in welfare perceptions among five herptile species. Visitor perceptions of animal welfare were consistent across all study locations. These findings demonstrate consistent expectations of animal welfare held by this sample of zoo visitors. Responses from zoo visitors in this study demonstrate that they perceive zoos are successfully meeting the physical needs of herptiles but could improve upon meeting the affective needs of the animals.

Ortega, F., Armenteros, I., De Celis, A., Escaso, F., Huerta, P., de Jesús, S.M., Narváez, I., Pérez-García, A. and Sanz, J. (2022). Crocodyliformes and Testudines from the Eocene of the Duero Basin (northwestern Spain): an update of their diversity and stratigraphic context. Historical Biology (https://doi.org/10.1080/08912963.2022.2051503).

Abstract: The Palaeogene sedimentary successions of the Duero Basin host an important record of fossil vertebrates, especially mammals and reptiles. The main fossil sites are placed at the west margin (Salamanca and Zamora areas) spanning from the Lutetian to the late Priabonian; and at the southeast tip (Almazán Basin) mainly Bartonian in age. The continued study of the sites is supplying new data that will improve the chronostratigraphy and the correlation between the western and eastern regions of the basin. The diversity and phylogenetic relationships of the represented fauna have been revised in recent years with the reassignment of some remains and the diagnosis of some new taxa. Four lineages of turtles are represented: Podocnemididae (*Neochelys*), Carettochelyidae (*Allaeochelys*), Trionychidae and Testudinidae (*Pelorochelon*). Crocodyliform paleobiodiversity is composed of notosuchians (close to *Iberosuchus*) and, at least, three crocodylian lineages: Planocraniidae (*Duerosuchus*), Alligatoroidea (*Diplocynodon*) and Crocodyloidea ('*Asiatosuchus*'). The distribution of these taxa is not homogeneous throughout the basin, and a deep transformation is recognised throughout the middle Eocene. The fitting of the distribution and relationships of the reptilian fauna from the Duero Basin provides valuable information to understand some faunistic dynamics such as the endemism process of northwestern Iberia from the middle of the Eocene.

Dallas, J.W. and Warne, R.W. (2022). Captivity and animal microbiomes: Potential roles of microbiota for influencing animal conservation. Microbial Ecology (https://doi.org/10.1007/s00248-022-01991-0).

Abstract: During the ongoing biodiversity crisis, captive conservation and breeding programs offer a refuge for species to persist and provide source populations for reintroduction efforts. Unfortunately, captive animals are at a higher disease risk and reintroduction efforts remain largely unsuccessful. One potential factor in these outcomes is the host microbiota which includes a large diversity and abundance of bacteria, fungi, and viruses that play an essential role in host physiology. Relative to wild populations, the generalized pattern of gut and skin microbiomes in captivity are reduced alpha diversity and they exhibit a significant shift in community composition and/or structure which often correlates with various physiological maladies. Many conditions of captivity (antibiotic exposure, altered diet composition, homogenous environment, increased stress, and altered intraspecific interactions) likely lead to changes in the host-associated microbiome. To minimize the problems arising from captivity, efforts can be taken to manipulate microbial diversity and composition to be comparable with wild populations through methods such as increasing dietary diversity, exposure to natural environmental reservoirs, or probiotics. For individuals destined for reintroduction, these strategies can prime the microbiota to buffer against novel pathogens and changes in diet and improve reintroduction success. The microbiome is a critical component of animal physiology and its role in species conservation should be expanded and included in the repertoire of future management practices.

Leiva, P.M.L., Valli, F.E., Piña, C.I., González, M.A. and Simoncini, M.S. (2022). Chemical characterization and potential use of reptile fat from sustainable programs. Ethnobiology and Conservation (doi:10.15451/ec2022-03-11.06-1-12).

Abstract: Reptile meats and fats are used for their medicinal properties and nutritional values perceived through the culture of native peoples, though often with no scientific basis. Providing scientific information about potential medicinal and nutritional use of reptile fats would be a strategy for the full use of wild animals,

supporting the sustainable use and conservation of biodiversity. The objective of this study was to characterize and chemically compare the fat and oil of individuals of Argentine Black and white tegu (*Salvator merianae*) and Broad-snouted caiman (*Caiman latirostris*) from sustainable use and conservation programs. In addition, we evaluated the microbiological characteristics and the antimicrobial activity of the oils obtained by different methods. We used two methodologies to obtain oils, one by fusion extraction and the other by drying-decantation (traditional hunter's method). We obtained the chemical and microbiological characterization of fat and oil of *C. latirostris* and *S. merianae*. All the oil samples presented less than 10 CFU/ml of all the microorganisms tested. *C. latirostris* and *S. merianae* oil showed nutritional quality parameters that indicate its potential use. Furthermore, *S. merianae* oil showed antimicrobial activity against *Staphylococcus aureus* and *Candidas tropicalis*. No inhibition occurs for the rest of the microorganisms analyzed. *C. latirostris* oil did not show antimicrobial activity, although the lipid profile does indicate some anti-inflammatory potential. This study demonstrates the potential application of the tested oils and confirms the pharmacological basis for the traditional therapeutic use of *S. merianae* oil.

Gour, R., Whitaker, N. and Kartik, A. (2022). Status and distribution of Mugger crocodile *Crocodylus palustris* in the southern stretch of river Cauvery in Melagiris, India. Journal of Threatened Taxa 14(3): 20733-20739.

Abstract: A study was conducted to examine the population estimate and spatial distribution of Mugger Crocodile in the southern stretch of river Cauvery, Hosur Forest Division from February 2019 to May 2019. In total, 53 basking sites and 45 Muggers were encountered by direct sighting in the 24-km river stretch using daytime ground based survey approach. N-mixture models estimated an average Mugger density of 2.05 individuals per kilometre for daytime survey. A night spotlight survey across the seven segments of river stretch was also conducted which yielded direct sightings of 54 Muggers with an average encounter rate of 2.25 individuals per kilometre. Two crocodile nests with hatched egg shells were also observed on the sand banks of the river. We concluded that a potential healthy and breeding population of Mugger inhabits the studied stretch of the river. Multiple corresponding analysis was also performed, which demonstrated that Mugger responds to sandy banks alongside deep water pools for basking in contrast to river segments with shallow depth and dense riparian cover.

Schwab, J.A., Young, M.T., Walsh, S.A., Witmer, L.M., Herrera, Y., Timmons, Z.L., Butler, I.B. and Brusatte, S.L. (2022). 'Ear stones' in crocodylians: a cross-species comparative and ontogenetic survey of otolith structures. Royal Society Open Science 9(3): 211633.

Abstract: The vestibular system of the inner ear is a crucial sensory organ, involved in the sensation of balance and equilibrium. It consists of three semicircular canals that sense angular rotations of the head and the vestibule that detects linear acceleration and gravity. The vestibule often contains structures, known as the otoliths or 'ear stones'. Otoliths are present in many vertebrates and are particularly well known from the fossil record of fish, but surprisingly have not been described in detail in most tetrapods, living or extinct. Here, we present for the first time a survey of the otoliths of a broad sample of extant crocodylian species, based on computed tomography scans. We find that otoliths are present in numerous crocodylian species of different growth stages, and they continue to increase in size during ontogeny, with positive allometry compared to skull length. Our results confirm that otoliths are a common component of the crocodylian vestibular system, and suggest they play an important role in sensory detection. Otoliths are likely common, but overlooked, constituents of the inner ear in tetrapods, and a broader study of their size, shape and distribution promises insight into sensory abilities.

Greer, S., Cramberg, M.J. and Young, B.A. (2022). Morphometrics of the spinal cord and surrounding structures in *Alligator mississippiensis*. Biology 11(4): 514 (https://doi.org/10.3390/biology11040514).

Abstract: Morphometric analysis of the spinal cord and surrounding tissue of the American alligator (*Alligator mississippiensis*) reveals that there are four significantly discrete regions; cervical, thoracic, lumbar, and caudal. Crocodylians, unlike mammals, have a caudal spinal cord that extends throughout the length of their tail (which accounts for roughly 50% of their total body length). *Alligator mississippiensis* has one of the largest ranges of body sizes among terrestrial vertebrates, this study documents how the different spinal structures change with increasing body size. Though most of the structures exhibit slightly positive allometry, a few exhibit slightly negative allometry; these differences mean that there are significant relational changes as hatchlings grow into large adults. This study provides the first documentation that *A. mississippiensis* has an expansive subdural space, a lumbar cistern, at the pelvis.

Alheit, B., Bargmann, S. and Reddy, B.D. (2022). How suture networks improve the protective function of natural structures: A multiscale investigation. Acta Biomaterialia (doi: 10.1016/j.actbio.2022.03.037).

Abstract: Myriad natural protective structures consist of bone plates joined by convoluted unmineralized (soft) collagenous sutures. Examples of such protective structures include: shells of turtles, craniums of almost all animals (including humans), alligator armour, armadillo armour, and others. The function of sutures has been well researched. However, whether, and if so how, sutures improve protective performance during a predator attack has received limited attention. Sutures are ubiquitous in protective structures, and this motivates the question as to whether sutures optimize the protective function of the structure. Hence, in this work the behaviour of structures that contain sutures during predator attacks is investigated. We show that sutures decrease the maximum strain energy density that turtle shells experience during predator attacks by more than an order of magnitude. Hence, sutures make turtle shells far more resilient to material failure, such as, fracture, damage, and plastic deformations. Additionally, sutures increase the viscous behaviour of the shell causing increased dissipation of energy during predator attacks. Further investigations into the influence of sutures on behaviour during locomotion and breathing are also presented. The results presented in this work motivate the inclusion of sutures in biomimetically designed protective structures, such as helmets and protective clothing.

McElroy, E.J. and Granatosk, M.C. (2022). The evolution of asymmetrical gaits in gnathostome vertebrates. Journal of Experimental Biology (doi: 10.1242/jeb.243235).

Abstract: The difficulty of quantifying asymmetrical limb movements, compared with symmetrical gaits, has resulted in a dearth of information concerning the mechanics and adaptive benefits of these locomotor patterns. Further, no study has explored the evolutionary history of asymmetrical gaits using phylogenetic comparative techniques. Most foundational work suggests that symmetrical gaits are an ancestral feature and asymmetrical gaits are a more derived feature of mammals, some crocodilians, some turtles, anurans and some fish species. In this study, we searched the literature for evidence of the use of asymmetrical gaits across extant gnathostomes, and from this sample (n= 308 species) modeled the evolution of asymmetrical gaits assuming four different scenarios. Our analysis shows strongest support for an evolutionary model where asymmetrical gaits are ancestral for gnathostomes during benthic walking and could be both lost and gained during subsequent gnathostome evolution. We were unable to reconstruct the presence/absence of asymmetrical gaits at the tetrapod, amniote, turtle and crocodilian nodes with certainty. The ability to adopt

asymmetrical gaits was likely ancestral for Mammalia but was probably not ancestral for Amphibia and Lepidosauria. The absence of asymmetrical gaits in certain lineages may be attributable to neuromuscular and/or anatomical constraints and/or generally slow movement not associated with these gaits. This finding adds to the growing body of work showing the early gnathostomes and tetrapods may have used a diversity of gaits, including asymmetrical patterns of limb cycling.

Conover, M.R. and Conover, D.O. (2022). Human-Wildlife Interactions From Conflict to Coexistence. 2nd Edition. CRC Press: Boca Raton.

Summary: This second edition of "Human-Wildlife Interactions: From Conflict to Coexistence" provides a comprehensive review of the severity of human-wildlife interactions and the methods used to resolve them.

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